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## CONTENTS

ARTICLES PAGE

Exploratory Studies on the Control of Adult Mosquitoes and Blackflies with DDT Under Arctic Conditions. J. B. Goldsmith, C. N. Husman, A. W. A. Brown, W. C. McDuffie and J. F. Sharp ..... 93

Heavy Ground Aerosol Generators for the Control of Adult Biting Insects in Alaska. C. S. Wilson, K. H. Applewhite and L. M. Redlinger ..... 97

Studies Using DDT Applied in Airplane Thermal Exhaust Aerosols for the Control of Anopheline Larvae in Rice Fields in California ..... Harvey I. Magy 101

Larvicide Tests on Blackflies in New Hampshire. J. B. Kindler and F. R. Regan ..... 108

Rearing of *Anopheles quadrimaculatus* Say and *Aedes aegypti* (L.) in the Laboratory. A. H. Casanges, E. R. McGovran, and J. V. Chiles ..... 112

NEWS AND NOTES ..... 118

ASSOCIATION NEWS

Joint Meeting of the American and Virginia Associations ..... 120

EDITORIAL SECTION ..... 122

REVIEWS AND ABSTRACTS

The Natural History of Mosquitoes. By Marston Bates ..... F. C. Bishopp 123

Control of Rural Malaria with DDT. By D. K. Viswanathan and T. Ramachandra Rao ..... Helen Sollers 124

Aircraft and Public Health Service Foreign Quarantine Entomology. By J. H. Hughes ..... Author's Summary 124

Da Aplicação Extradomiciliar de Hexaclorobenzeno por Meio de Helicóptero no Combate Aos Anofelinos do Sub-Gênero Kerteszia em Matas Primarias com Predominância de Bromélias Epífitas. By M. O. Ferreira, R. G. Rachou and F. M. Bustamente ..... W. H. W. Komp 125

Alameda County Mosquito Abatement District, 1949 Annual Report. By Harold F. Gray ..... Fred H. Stutz 125

Da Aplicação Extradomiciliar de DDT por Helicóptero no Combate Aos Anofelinos do Sub-Gênero Kerteszia em Matas Primárias com Predominância de Bromélias Epífitas. By F. M. Bustamente, M. O. Ferreira and R. G. Rachou ..... W. H. W. Komp 126

Expert Committee on Insecticides ..... H. L. F. 126

Filariasis Control by DDT Residual House Spraying, Saint Croix, Virgin Islands. I. Operational Aspects. By Charles E. Kohler ..... Author's Summary 126

Filariasis Control by DDT Residual House Spraying, St. Croix, Virgin Islands. II. Results. By H. W. Brown and R. W. Williams ..... Author's Summary 126

Mosquito Control of Richland, Washington, In View of Operations of 1948 ..... C. T. Williamson 127

The Place of New and Old Insecticides in Mosquito Control in New Jersey. By J. M. Ginsberg, D. M. Jobbins and T. D. Mulhern ..... P. B. Brockway, Jr. 127

Implication of the Mosquito *Aedes (Stegomyia) africanus* Theobald in the Forest Cycle of Yellow Fever in Uganda. By A. J. Haddow, K. C. Smithburn, G. W. A. Dick, S. F. Kitchen and W. H. R. Lunsden ..... Author's Summary 127

Catches of Biting Diptera in Uganda, with Anaesthetized Monkeys as Bait. By A. J. Haddow and G. W. A. Dick ..... Author's Summary 127

Recovery of Anopheline Eggs from Natural Habitats, An Aid to Rapid Survey Work. By T. H. G. Aitken ..... H. L. T. 128

A Malaria Reconnaissance of the State of Veracruz, Mexico. By J. B. Castellanos, L. C. Murrieta, G. Lassman, and C. Ortiz ..... H. L. T. 128

The Development and Practices of the Anti-Malaria Campaign in Argentina. By L. A. Silvetti .. R. F. Peters 128

GENERAL BIBLIOGRAPHY ..... 130

LIST OF ADVERTISERS ..... XI

ADVERTISING RATES ..... 129

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# ARTICLES

## EXPLORATORY STUDIES ON THE CONTROL OF ADULT MOSQUITOES AND BLACKFLIES WITH DDT UNDER ARCTIC CONDITIONS [1]

JOSEPH B. GOLDSMITH, C. N. HUSMAN, A. W. A. BROWN, WM. C. McDUFFIE, AND J. F. SHARP [2]

Tests with both light and heavy aircraft and other types of equipment for the dispersal of DDT in the control of adult mosquitoes have been reported by Deonier *et al.* (1945), Lindquist *et al.* (1945), the Army Air Forces Committee on Aerial Dispersal of Insecticides (unpublished), and many others. To determine whether such methods of area control of adult insects would be applicable under arctic conditions, the authors undertook a preliminary test program during the summer of 1947 at Churchill, Manitoba, Canada. The program included exploratory studies on the control of adult mosquitoes, of arctic and subarctic species, and blackflies by means of aerial and ground dispersal equipment to obtain information relative to the suitability of methods and equipment, as well as dosages of DDT necessary for control under conditions of the far north. Additional work was devoted to the possibility of obtaining temporary control and protection from mosquitoes and blackflies by treating small areas with aerosol bombs, smoke bombs, and hand-spraying equipment. The results of these studies are given in this paper.

Test Conditions.—Aerial spray tests were conducted on both open tundra and swampy forest typical of the Churchill area. The open tundra was flat and marshy, with low-growing vegetation, predominantly lichens, mosses, and grasses. The forested tract consisted of thin stands of larch and spruce 15 to 30 feet in height intermixed with thin to dense stands of dwarf willow and birch 2 to 6 feet in height. The whole formed only a relatively light vegetative canopy, as compared with the average forest or jungle, and presented no real obstacle to penetration with sprays applied from ground or air. Aerial spray plots embraced from 300 to 1,700 acres of such terrain. Other tests conducted on similar terrain involved small areas of 1 to 2 acres treated with hand sprayers to over 100 acres treated with a power sprayer.

The aerial spray tests were conducted early in July when adult mosquito populations were very large and rapidly increasing. Larval and pupal populations were fairly high but were declining. Although only a few blackfly adults were present at this time, streams within the plots contained an abundance of immature stages. During the latter half of July, small-scale tests with hand sprayers, aerosol and smoke bombs, and a power sprayer were made when adult mosquito populations had reached their peak or were declining, but when blackflies were abundant and apparently increasing.

The weather was relatively mild during the period in which aerial spray tests were conducted. The maximum daily temperatures ranged from 52° to 64° F. Wind

[1] The results herein reported were obtained through the joint efforts of the Canadian Division of Entomology on behalf of the Canadian Defense Research Board and the U. S. Bureau of Entomology and Plant Quarantine on behalf of the Army Committee on Insect and Rodent Control.

[2] Lt. Col. MSC, U. S. Army (now associate professor of preventive medicine and public health, University of Oklahoma School of Medicine); U. S. D. A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine; Canadian Defense Research Board; U. S. Bureau of Entomology and Plant Quarantine; and Division of Entomology, Science Service, Canadian Department of Agriculture, respectively.

Acknowledgment is made of the valuable contributions of the following members of the joint party: H. F. Cross, U. S. group; C. R. Twinn, B. Hocking, and R. W. Fisher, Canadian group.

velocities varied, but, with one exception, tests were carried out when winds were less than 10 m.p.h. The small-scale tests were conducted under much the same meteorological conditions except that periods with wind velocities generally exceeding 10 m.p.h. were selected to facilitate dispersion of the insecticide.

Methods and Materials.—Four aerial dispersal tests were made with a R. C. A. F. Dakota (C-47) aircraft equipped with cargo tanks and a simple gravity-flow discharge device consisting of a vertical, round, 3⅜-inch pipe extending 14 inches below the fuselage. The discharge pipe was cut at an angle of 45 degrees at the side facing the tail of the plane to minimize the flow interference during flight. The average discharge rate was 94 imperial, or 112 U. S. gallons per minute. In flight the flow of liquid streamed just below the fuselage, but much of it impinged upon the tail assembly and was swept off by air turbulence. The size of particles, as determined by measurements from a series of white cards, ranged from 40 to 1,360 microns in diameter, the average being approximately 250 microns. A 5 per cent DDT-fuel-oil solution (wt./vol.) was used in all the tests. Since the rate of discharge could not be changed, a change of dosage was obtained by varying the swath interval from 100 to 200 yards. Except for the first test, the height of flight was maintained as nearly as possible at 100 feet.

The pound-per-acre deposition of DDT, as shown in table 1, was computed from the discharge rate of the equipment employed. This figure gives only the total amount of material released, but the effective DDT dosages are probably much lower.

A power sprayer was not available for ground test work, but a suitable unit was constructed, consisting of a gear pump powered by a ¼-hp. gasoline engine and a 12-foot vertical boom equipped with six mist-spray nozzles. This equipment was mounted on a "Weasel," cargo carrier, M-29, with the top outlet being approximately 16 feet from the ground. When operated at a pressure of 50 pounds per square inch, this unit dispersed approximately 2 gallons of solution per minute. Two tests were conducted with this sprayer at a dosage of approximately 2 U. S. quarts of 10 per cent DDT-xylene-fuel-oil solution (approximately 0.35 pound of DDT) per acre. The swath interval varied from 150 to 200 yards, depending upon wind velocity.

Mosquito populations were estimated at established counting stations in each plot before spraying and at intervals thereafter until adult abundance rose to a level equal to that of untreated check areas. Relative abundance was determined by counts of those landing on the front of a man's trousers over a period of 1 minute. The percentage control of adults was calculated on the basis of counts before and after treatment, but check areas were kept under observation to confirm the fact that reductions were due to treatments and not to natural factors. This routine was also followed in evaluating small-plot tests, except that observations were made immediately and at shorter intervals after treatment.

Aerial Spray Tests.—The detailed results of the four tests are presented in table 1. In the first test there was no significant reduction of mosquitoes 24 hours after treatment. After 48 hours mosquitoes were more numerous than prior to the treatment. Several reasons may be advanced for this failure, namely, inadequate dosage due to the wide swath interval, excessive flying height, insufficient atomization of the spray solution, or rapid reinvasion of the plot from surrounding heavily infested areas.

In the second test an extremely heavy population of adult mosquitoes was almost completely eliminated for 4 days after spraying, but thereafter infiltration was so rapid that the population was fully restored within 8 days.

In test 3 the swath interval was the same as in test 1 (600 feet), but the area covered was twice as large and the height of flight was less than 100 feet. There was no reduction of adults 6 hours after treat-

TABLE 1.—Results of aerial spray tests with a 5 per cent DDT-fuel-oil solution against adult mosquitoes of arctic and subarctic species.

| Plot Number | Type of Vegetation in Area | Size of Plot (Acres) | Average Temperature (° F.) | Wind Speed (M.p.h.) | Height of Flight (Feet) | Swath Interval (Feet) | Dosage per Acre | | Per Cent Reduction of Adults at Indicated Intervals After Treatment | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | DDT (Pound) | Oil [1] (Gallon) | 6 Hours | 24 Hours | 48 Hours | 4 Days | 6 Days | 8 Days |
| 1 | Dwarf birch and willow; scattered spruce-larch | 310 | 54 | 2.5–5.0 | 123–202 | 600 | 0.26 | 0.51 | – | 12.5 | 0 | – | – | – |
| 2 | Largely spruce-larch forest | 728 | 60 | 4–8 | 50–180 | 300 | .48 | .96 | 99.8 | – | 99.8 | 99.1 | 84.0 | 0 |
| 3 | Mixed spruce-larch wood and dwarf birch and willow | 654 | 52 | 8–10 | 45–90 | 600 | .26 | .51 | 0 | 92.0 | 70 | 0 | – | – |
| 4 | Camp area, sparsely wooded ridge and tundra | 1,781 | 64 | 10–28 | 50–180 | 300 | .44 | .89 | – | 79.0 | – | 0 | – | – |
| Control | Similar to plots 1, 2, and 3 | – | – | – | – | – | – | – | 0 | 0 | 0 | 0 | 0 | 0 |
| | Similar to plot 4 | – | – | – | – | – | – | – | 0 | 0 | – | 60 | – | – |

[1] Imperial gallons.

ment, but after 24 hours the count declined 92 per cent. The population was fully restored 4 days after treatment. Since the actual time of spraying in test 3 overlapped that of test 2, and the population recovery in test 3 was much faster than that in test 2, it is possible that the recovery in test 3 was due mainly to emergence of unaffected immature stages rather than to rapid infiltration. About half this area was covered with vegetation, and the stand was much thinner than in test plot 2.

In test 4 the spraying operation was the same as in test 2, but the wind velocity was higher. A 79 per cent reduction of adult mosquitoes was indicated 24 hours after treatment, but the population was restored within 4 days.

The best results were obtained in test 2, in which the DDT discharge rate was about 0.5 pound per acre, the swath interval was 300 feet, and the area was more or less forested. Apparently the swath widths in tests 1 and 3 were excessive as compared with the delivery rate of the plane equipment and the rather large droplet sizes. The ineffectiveness of the fourth test was probably due principally to the high wind velocity, which in the absence of vegetation prevented normal settling of the small particles of spray. In test 2 the heavier stand of trees and bushes, which served as a windbreak, probably permitted the settling of a large proportion of the finer spray droplets, and may also have retarded the rate of mosquito reinfiltration. Under these relatively favorable conditions, however, the protection afforded by covering a square mile was little over a week's duration.

Power Sprayer Tests.—Tests with ground-operated power equipment were carried out on two plots, one of 118 acres and one of 130 acres, at a dosage of 0.35 pound of DDT per acre. In the first test the reduction of mosquitoes and blackflies after 24 hours was 99.8 per cent. Within 48 hours, however, infiltration from surrounding areas had commenced, and 4 days after treatment the landing rates were again estimated at 100 plus per minute. In the second test the 48- and 72-hour counts showed a reduction of 81 per cent, but the general mosquito population declined so rapidly at this time that the results were of little significance. This decline of the general mosquito population probably indicated the natural ending of the "mosquito season."

Incidental observations indicated that tabanids were affected little, if at all, by the sprays. Blackflies tended to reinfest the sprayed plots quicker than mosquitoes, but their activity was too sporadic to permit satisfactory counts.

Small-Plot Tests.—Four tests were conducted on lightly forested plots 1 to 2 acres in size. Dosages of 1 to 2 quarts per acre of DDT-fuel-oil solution were applied with a knapsack-pressure sprayer equipped with a mist-producing nozzle. The swath intervals were about 30 feet. The higher dosage provided an effective, but only temporary, reduction of mosquitoes and blackflies. Infiltration began almost immediately after spraying, and a heavy population was restored within 15 minutes to an hour. The blackflies, in annoying numbers, appeared to return to the treated areas sooner than the mosquitoes. Similar results were obtained in tests with pyrethrum and pyrethrum-DDT aerosol bombs, and with DDT-nicotine and benzene hexachloride smoke bombs. In each case, protection lasted only for a brief period. It was concluded, therefore, that small-area treatments of this type, which have been reported as effective in jungle or heavily forested areas (Gorgas Memorial Laboratory, p. 23), were of little value under the conditions at Churchill.

Summary.—In a cooperative study of mosquito control at Churchill, Manitoba, Canada, four aerial spraying tests with DDT were conducted with a R. C. A. F. Dakota (C-47) airplane against adult mosquitoes. In one test on a forested plot a mile square treated at the discharge rate of about 0.5 pound of DDT per acre, excellent control was obtained for 4 to 6 days, after which the plot became reinfested. The swath interval was 300 feet and the flying height approximately 100

feet. A similar treatment over open terrain and at higher wind velocities did not give effective control. With two treatments at a discharge rate of 0.26 pound of DDT per acre and a swath width of 600 feet, no reduction occurred in one of the plots and only temporary reduction in the other.

Two plots of 118 and 130 acres were treated with a ground-operated power sprayer at a dosage of 0.35 pound of DDT per acre. One treatment effectively reduced the number of both mosquitoes and blackflies for 24 hours, but reinfestation began within 48 hours. The results of the second test were questionable because a natural reduction occurred in untreated areas.

Small-plot tests with DDT sprays, pyrethrum and pyrethrum-DDT aerosols, and DDT-nicotine and benzene hexachloride smoke bombs gave temporary reduction of mosquitoes and blackflies, but the plots became reinfested within 15 minutes to an hour, an indication that such measures were of little practical use. The blackflies appeared to return into the treated areas sooner than the mosquitoes.

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# HEAVY GROUND AEROSOL GENERATORS FOR THE CONTROL OF ADULT BITING INSECTS IN ALASKA [1]

CHARLES S. WILSON,[2] K. H. APPLEWHITE,[3] AND L. M. REDLINGER,
U. S. D. A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine [4]

The usefulness of heavy ground equipment for generating aerosols for the control of adult *Culicoides,* mosquitoes, and blackflies was investigated under three types of Alaskan conditions during the summer of 1947. Tests were made in a small town with cross streets, in a small, wooded area encircled by roads, and in a third and more typical area traversed by a single road nearly 20 miles long. No unusual weather was encountered during the tests. Inversion or isothermic air temperatures occurred nearly every evening with few periods of strong breeze. Although little is known about the flight habits of these insects, there was probably little deviation from normal in the mild weather that prevailed during the tests.

The generators, a modified Besler (Chemical Corps designation E-15) and a large Hession, were mounted on a trailer towed by a ¾-ton truck. The Besler generator was operated at 600° F. and at a delivery rate of 40 gallons per hour. The Hession generator was a new machine of a type devised to produce a mist spray by throwing droplets from a set of rapidly revolving discs. The maximum flow rate was said to be 140 gallons per hour. The droplet size produced by both these generators was not determined.

[1] This work was conducted under funds allotted by the National Military Establishment to the Bureau of Entomology and Plant Quarantine.

[2] Now with the U. S. Public Health Service, Alaska Health and Sanitation Activities.

[3] Captain, Quartermaster Corps, U. S. Army.

[4] Lee Norris, Chemical Corps, U. S. Army, operated the aerosol generators and furnished valuable assistance with other phases of the work. F. H. Convey, Chemical Corps, assisted with the insect counts.

The solution used in the Besler was 25 gallons of Navy Fog Oil, 15 gallons of fuel oil, 8 gallons of Velsicol AR-60, (chiefly di- and trimethyl naphthalenes) and 25 pounds of DDT. The solution used in the Hession generator was 5 per cent of DDT dissolved in fuel oil.

### CONTROL OF CULICOIDES IN A SMALL TOWN

Valdez, a town with a population of approximately 600, was used for the tests to control *Culicoides*. This town covers an area of about 1 square mile on a gravel flat between a mountain and a bay. At one side of the town a tidal marsh extends for several miles along the base of the mountain, and a river and flood plain lie on the other side. There are good roads around the landward sides of the town and adequate cross streets, almost to the high-tide line to allow swaths to be made 1 block apart. No roads are present along the base of the mountain or on the seaward side of the salt marsh. When the tests were made, the vegetation was dense and rank except in the thickly populated parts of the town.

The weather was "good" for Valdez between July 17 and 20, when the tests were made, as there was no rain or strong wind and the temperature did not become low enough to interfere with insect activity. The tests were made on two consecutive nights, during the temperature inversion of each evening, when a light breeze blew down the mountain, across the town, and out over the bay.

The first swath in each test was laid around the landward sides of the town with the Besler generator and then the generator was driven along the streets so that the coverage would be complete and fairly uniform. A lighter, second treatment was made by following essentially the same routes but at twice the speed. Much of the visible part of the cloud drifted across the town and out over the bay.

Estimates of population densities were based on the number of *Culicoides* resting on an observer's hat after a 3-minute wait at the counting station. Tests were made on 2 nights. Two stations were observed by the same persons both nights and two were not observed until the second night. A few blackflies and enough mosquitoes to be annoying were present at some of the stations, but the numbers were not sufficient to give significant counts. The mosquitoes appeared to be controlled effectively by the treatment.

In the first test a large initial population of sand flies was sharply reduced, but not eliminated, by the use of 50.5 gallons of 6.6-per cent (weight by volume) DDT solution (about 0.04 pound of DDT per acre). Counts at one station dropped from an average of 152 to 2.7 after a cloud of aerosol had passed. Counts at the other station went from 183 to 15 on passage of a light cloud, and down to 1.5 on passage of a dense cloud. Preliminary counts were low (average 13) at all stations on the second night, and only 27 gallons of solution were dispersed, about 0.022 pound of DDT per acre. Very thin clouds of aerosol passing over three of these stations had little effect, but passage of the main clouds brought the average of the combined counts down to 3.3, a level that would probably afford practical relief to the inhabitants of the town.

### CONTROL OF MOSQUITOES AND BLACKFLIES IN AN AREA SURROUNDED BY ROADS

Only one suitable area surrounded by roads but without adequate cross roads, was found before the tests made to control mosquitoes and blackflies were terminated by stormy weather. This area, near Slana, was a wooded triangle about ½ mile long and ¼ mile wide at the base. Good roads extended along each leg of the triangle and up a hill that formed the base. This hill was about 70 feet high and dropped abruptly to the level land below. There was a connecting road along the top of the hill and a passable track at the bottom of it.

With a 7-mile-per-hour wind blowing directly toward the apex of the triangle, the Hession generator was driven slowly

and with frequent stops along the connecting road at the top of the hill. Instead of the aerosol drifting over the flat, wooded area below, the wind swirled just beyond the brow of the hill and tended to carry the aerosol to one side of the triangular, wooded area.

The machine was then driven along the roads that formed each leg of the triangle, and an attempt was made to find some place from which at least a part of the plot could be treated. The drafts of air blew down each road, so that the aerosol did not reach beyond the edge of the cleared roadway. Even when the generator was driven along the track at the foot of the hill, the aerosol was drawn into the turbulence at the edge of the hill and toward the drafts blowing down the roads. Glass slides placed in two rows at right angles to the track showed deposits only to a distance of 100 feet. In these tests about 30 gallons of Diesel oil containing 5 per cent of DDT were dispersed in about 25 minutes. Cold rains prevented adequate checking of the insect population after treatment, but there was no evidence of reduction attributable to the aerosol.

### CONTROL OF MOSQUITOES AND BLACKFLIES IN AN AREA TRAVERSED BY A SINGLE ROAD

The tests to determine the feasibility of controlling blackflies and mosquitoes under the third type of Alaskan condition were made on a series of selected plots on the road between Slana and Nabesna. Low but fairly uniform insect populations were found over a section of nearly 20 miles. The lower end of this road ran near the middle of a flat valley floor several miles wide. The valley narrowed at the upper end and the road ran close to the adjoining mountain. The vegetation consisted chiefly of scattered spruce interspersed with dwarf birch and the usual moss and small heath plants.

It was soon found that the air movements in the valley assumed fairly definite patterns. The prevailing wind movement during the tests was up the valley and therefore parallel to the road. In calm weather the air currents paralleled the lower part of the road during both lapse and inversion. They crossed the road only along the upper part. Practical treatment was therefore limited to about one-fourth the total roadside area—that is, to those areas reached by inversion currents moving across the road. Three attempts were made to reach plots on the opposite side by operating just at the time of the morning reversal of air movement, but all ended in failure due to thermal turbulence. Even with good inversion there was some difficulty due to turbulence of a different sort. The cool air draining down canyons and gullies tended to flow and eddy around obstructions so that a number of locations could not be reached. In a few cases this tendency could be used to advantage to fill a natural pocket.

A camp was established and maintained for 6 days at the upper end of the valley in what appeared to be an excellent site for demonstrating the protection to be obtained from aerosols. Two low hills about 1,000 feet apart and a small lake partially delimited this space of about 64 acres. The air movement during inversion was across the road and into the area. Treatments were applied with the Besler generator on 2 consecutive days.

In the first treatment 25.7 gallons of solution were dispersed on a 0.53 mile front, or about 0.21 pound of DDT per acre to be protected. The front was extended on the second day to 0.7 mile so that better coverage could be secured, and 28.2 gallons were delivered, or about 0.22 pound of DDT per acre to be protected. Inversion was good at the time of both treatments, and the drift into the trees was excellent.

Landing rates were too low and erratic to give satisfactory measures of the insect populations in the test area. The men had to wait 2 minutes at each counting station and then estimate the numbers of blackflies and mosquitoes around them. Although these estimates were not adequate for fine comparisons, it was evident that both blackflies and mosquitoes were present in distinctly annoying numbers 15 hours after

the first treatment. Immediately after the second treatment the number of mosquitoes was considerably reduced, but a great many blackflies were still present.

Blackfly and mosquito activity practically ceased during the middle of the day and late at night, so that counts after a treatment usually could not be made until the next active period. In 10 attempts to clear roadside areas, no satisfactory evidence of 24-hour protection was obtained. Even with fronts of a half mile, the depth of the area effectively reached was not sufficient to prevent reinvasion at the next period of activity. There is some reason to believe that the blackflies were not killed by the aerosols used. They were present in the camp area as soon as the men returned from making each treatment. It was thought possible that they had followed the men in from outside areas; so the camp was thoroughly smoked twice within a half hour, with a DDT insecticide candle (E-22) tied to a stick and carried around the camp. Each time the flies were back a few minutes after the smoke cleared.

A short track was found over which a vehicle could be moved at right angles to the road. This track was used one evening, when the wind was blowing parallel to the road at 6 to 10 miles per hour, to treat a short front with the Hession generator. Sixteen and a half gallons of Diesel oil containing 5 per cent of DDT were dispersed on a 425-foot front. Counts made the next day failed to show definite effects on the mosquito and blackfly populations of the small area reached.

## DISCUSSION

Inability to reach the areas to be protected is the principal limitation to the use of aerosols generated by ground equipment. During the restricted weather conditions under which they can be used, i.e., inversion or isothermic conditions with low wind velocity, the air currents usually assume patterns that are fairly constant for each locality. Consequently, the only places available for treatment with heavy ground equipment are those with roads that are on the windward side under these particular conditions, and that have enough additional roads to allow sufficiently close swaths to be made and to take care of turbulence due to irregular terrain. Few places in Alaska have roads that satisfy all of these requirements.

Some towns, and probably some military posts and camps, could be treated cheaply and fairly effectively, but immediate reinfestation from surrounding areas should usually be expected. In Valdez, for example, the heavy populations of *Culicoides* just outside the town could not be reached from the single available road. Neither could the foothill area west of the town or the shore line to the east be reached with the equipment used.

## SUMMARY

Tests were made in a number of areas to determine the suitability of using heavy ground equipment for generating aerosols for control of biting insects in Alaska. Inability to reach the areas to be protected was found to be the principal limitation to the use of such equipment.

In a small town encircled by roads and with adequate cross streets to allow close swathing, a high initial population of *Culicoides* was reduced to a low level by dispersion of about 0.04 pound of DDT per acre to be protected. The next evening a much smaller, but distinctly annoying, population was reduced to a similarly low level by dispersion of only 0.022 pound of DDT per acre.

In an area surrounded by roads but without adequate cross roads, a single attempt made in a 7-mile-per-hour wind failed to control mosquitoes and blackflies because of air turbulence caused by the terrain.

In a wide valley traversed by a single road, only about one-fourth of the roadside area could be treated. The prevailing winds and the convection air currents assumed fairly constant patterns, which were nearly parallel to approximately half of the road. The convection currents crossed

the remaining half of the road, but only one side was treated because the aerosol could be used only during inversion, and air movements toward the other side occurred only during lapse conditions.

In a series of 10 tests with fronts up to a half-mile, the effective penetration was not sufficient to prevent reinvasion of mosquitoes and blackflies within 24 hours.

There was some evidence that blackflies were not readily killed by the aerosols used.

# STUDIES USING DDT APPLIED IN AIRPLANE THERMAL EXHAUST AEROSOLS FOR THE CONTROL OF ANOPHELINE LARVAE IN RICE FIELDS IN CALIFORNIA [1]

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## I. INTRODUCTION

The control of *Anopheles freeborni* (Aitken) larvae in California rice fields has always been a difficult task. Mosquito control ground crews are limited in the extent to which they can treat rice fields with spray equipment. Dr. Basil G. Markos (1949) has shown that in California anopheline larvae breed throughout a rice field, in the center as well as along the edges. Spray crews can treat only the edges of rice field checks, and are unable to penetrate the center of the checks with larvicides. Therefore airplane treatment would be a very desirable method of applying larvicides to cover the extensive area of individual rice fields.

Krusé and Metcalf (1946) successfully controlled anopheline larvae in impounded water by the use of DDT applied in airplane thermal exhaust aerosols. The Sutter-Yuba Mosquito Abatement District during 1946 conducted airplane thermal exhaust aerosol operations using similar equipment and techniques with apparent control of *Anopheles* larvae in rice fields.[2] The studies reported herein were conducted in the Sutter and Yuba Counties during routine control operations in 1947.

In cooperation with the Sutter-Yuba Mosquito Abatement District, the State Department of Public Health, Bureau of Vector Control, conducted fourteen studies during September, 1947, which were part of a routine program to treat 18,000 acres of rice in the vicinity of Yuba City and Marysville.

## II. OBJECTIVES

1. To determine if the thermal aerosol dispersal method was applicable for the control of anopheline larvae in rice fields in the Sutter-Yuba Mosquito Abatement District.
2. To determine the minimum dosage of DDT required to give 90% control of *A. freeborni* larvae in rice fields.
3. To determine the rapidity of recurrence of *A. freeborni* larvae after treatment in rice fields.

[1] This report is one of a series on continuing mosquito control operational and biological studies begun in 1946 by the Bureau of Vector Control, Division of Environmental Sanitation of the California State Department of Public Health in cooperation with various Mosquito Abatement Agencies.

[2] Unpublished records are in the permanent file of the Sutter-Yuba Mosquito Abatement District, Yuba, California.

4. To determine the economics of airplane applications of DDT larvicides for anopheline larval control in rice fields.

## III. EQUIPMENT AND TECHNIQUES

The equipment and techniques used in these studies were largely those developed by the Tennessee Valley Authority for the control of anopheline larvae with DDT aerosols produced by airplane exhaust aerosol generators as reported by Krusé and Metcalf (1946).

### *Airplane Equipment*

A converted Navy Primary trainer with a 300 horsepower motor was used in these studies. It was equipped with a 6" diameter exhaust stack that extended the length of the fuselage. A 2" venturi was fitted onto the end of the exhaust stack. Two flat spray nozzles obtained from an Essick ground sprayer, projected into the venturi. Essick WS-45-3 discs were used in each nozzle. The rate of discharge was between 1.8 to 2.5 gallons per minute. This was dependent upon the viscosity of the material, the pump pressure, the cleanliness of each spray disc, and the operating efficiency of the airplane engine.

A pressure of approximately 80 pounds was maintained by a wind-driven, fan-type pump, which was mounted on the upper surface of the lower wing.

### *Flight Data*

For the majority of the studies the airplane was flown at a height of 25 feet with 100-foot swaths paced off on the ground by one man. This swath gave an adequate distribution of the aerosol. Several studies were flown at 75-foot swaths in order to compare the effectiveness of this width with 100-foot swaths.

### *Measurement of Acreage*

Acreage was measured by determining the treatment time with a stop watch that was held by the pilot. Since the plane speed was practically constant at 80 miles per hour and the swath width of 100 feet was measured from the ground, it was easy to calculate the acreage treated by the plane in any given time by multiplying the swath width by the length of the field.

### *DDT Recovery and Droplet Studies*

Six floats were set out in the vegetation with four clear 1 x 3" glass slides on each float. In addition, one magnesium oxide-coated slide was placed on each of five of the floats. After the airplane treatment of a rice field, the slides were collected and the clear slides were chemically tested for DDT deposit. The magnesium oxide-coated slides were examined for droplet size distribution, mean diameter of the droplets and number of droplets in one square centimeter.

### *Meteorological Data*

(1) *Relative humidity* was determined with the use of a sling psychrometer.

(2) *Wind velocity* was determined with the aid of an anemometer. The wind velocity reading was taken three times during each flight, and an average of the three was recorded.

(3) *Conversion and Inversion Temperature* conditions were determined by placing a thermometer at one foot above the ground and another thermometer at six feet above the ground. A difference in temperature would indicate whether the air was rising or falling. If the 1-ft. reading was higher than the 6-ft. reading, this would give rising or conversion air currents. If the 1-ft. reading was lower than the 6-ft. reading, this would result in falling or inversion air currents.

For airplane aerosol application, inversion conditions are desirable, because of the slow settling rate of the smaller aerosol droplets. A majority of the flights were made early in the morning in order to take advantage of the inversion climatic conditions which were usually present at that time of day.

### *Water Factors*

The water in the rice fields originated from wells or irrigation canals. The water

tended to be slightly acid with a pH of 6.0 to 7.0, the pH being determined with pH Hydrion paper. Other water data included temperature, depth, and presence or absence of algae and flotage. The growth of the rice in the fields was considered to be of heavy vertical density and of medium height.

*Method of Selecting and Sampling Study Areas*

A single check of a rice field was selected for each study. Pre-treatment dips, 24 hour post-treatment, and other post-treatment dips were made at later dates. Three man-hours were devoted to each check. If two men were dipping, each dipped for one and a half hours; if three men were dipping, each dipped for one hour. Each man took two dips every four steps along the edge of the rice check. The dips were taken in multiples of ten. The surface of the water was skimmed for a distance of about 1½ feet with a white dipper attached to a five foot pole. The checks selected for the studies had their levees more or less at right angles to one another. Thus, each walked in a perpendicular direction to the other, so that during the airplane treatment, one man's series of checks would parallel the line of flight of the plane.

If the rice grew adjacent to the levee the men walked on the levee and dipped into the rice, but where "borrow" furrows were present and the rice was sparse in the furrows, they walked into the borrow furrows and dipped into the main stand of rice.

*Entomological*

*Anopheles freeborni* (Aitken) and *Culex tarsalis* (Coquillett) were the dominant species of mosquitoes found. *Anopheles franciscanus* (McCracken) and *Culex erythrothorax* (Dyar) were present in lesser numbers. Anopheline larvae were counted according to separate instars and pupae. *Culex* larvae were separated into three groups: First and second (1–2) instars, third and fourth (3–4) instars, and pupae.

Larval and pupal counts were taken 6–24 hours before treatment, and 24 hours after treatment. Post-treatment larval and pupal counts were made for the recurrence of anopheline larvae and pupae up to at least 14 days after treatment. The degree of control was based upon the per cent of larval reduction.

A large number of dips (130–230) were necessary in order to have sufficient larvae to give an analysis of the percentage of larval reduction. There was an average of at least one larva per dip, frequently two and three. There was considerable variation among the rice fields in the number and density of larvae.

*Materials Used*

A stock solution of a technical DDT concentrate in General Petroleum Distillate 544C (PD-544C), the basic material used, contained 1.71 pounds of DDT per gallon. This concentrate was diluted with diesel oil in various ratios. One study was made with straight diesel oil and DDT.

## IV. DISCUSSION OF RESULTS

*Toxicity Data*

The first eleven studies are summarized in Table 1, where they are listed according to the amount of DDT applied per acre. One study in which DDT and diesel oil alone was used and two of the studies in which 75-foot swaths were used are listed separately. It is evident that an average of 96.5% control of anopheline larvae was obtained in the studies with the exception of Nos. 1, 2, & 3 in which the disc from one of the nozzles was missing. The insecticidal solution was dispersed as a dense spray rather than as an aerosol.

Of significance was the fact that 98% anopheline larval control was obtained with as little as one pint of DDT solution per acre, which gave a dosage of 0.025 pounds of DDT per acre. These studies have not indicated an approach to the minimum lethal dosage of DDT per acre.

There were six studies with sufficient *Culex* larvae present to give significant data of larval reduction. A minimum of 100 *Culex* larvae per study in the pre-

treatment count was considered a significant number to be tabulated. Four of the six studies gave better than 98% larval control. Studies Nos. 2 and 5 resulted in a 64% and 63% larval reduction. The low larval reduction rate of study No. 2 may have been due to the fact that the disc of the larvicide injection nozzle was missing.

*Measured Factors*

Inspection of the data on the measured factors as listed in the following paragraph did not seem to indicate that the results were controlled by any single factor or combination of factors, since the results demonstrated above 85% control with the exception of one study.

The rate of application varied from 0.116 to 0.331 gallons per acre; pounds of DDT from 0.025 to 0.228 per acre; wind velocity from 0 to 10 miles per hour; relative humidity from 18 to 76%; inversion and conversion temperature differences from +1 to —4° F.; air temperature from 56° F. to 96° F.; water temperature from 59° F. to 73° F.; pH from 6.0 to 7.0; and water depth from 6″ to 24″. The mean droplet diameter for each study varied

TABLE 1.—Reduction of Mosquito Larvae in DDT Airplane Thermal Exhaust Aerosol-Treated Rice Fields in California, September, 1947

| Study No. | Material Used [2] | Swath | Lbs. DDT per Acre | Gallons Per Acre | *Anopheles* percentage reduction | *Culex* percentage reduction |
|---|---|---|---|---|---|---|
| 2 [1] | 2 gals. PD 544C—DDT Con.<br>3 gals. pure PD 544C | 100′ | 0.228 | 0.331 | 96.5 | 64.0 |
| 3 [1] | 1 gal. PD 544C—DDT Con.<br>4 gals. diesel oil | 100′ | 0.100 | 0.292 | 96.5 | – |
| 4 | 1 gal. PD 544C—DDT Con.<br>4 gals. diesel oil | 100′ | 0.062 | 0.176 | 99.5 | – |
| 5 | 1 gal. PD 544C—DDT Con.<br>4 gals. diesel oil | 100′ | 0.054 | 0.157 | 89.0 | 63.0 |
| 6 | 1 gal. PD 544C—DDT Con.<br>4 gals. diesel oil | 100′ | 0.054 | 0.157 | 100 | 100 |
| 12 | 1 gal. PD 544C—DDT Con.<br>4 gals. diesel oil | 100′ | 0.040 | 0.117 | 99.5 | 98.0 |
| 13 | 1 gal. PD 544C—DDT Con.<br>4 gals. diesel oil | 100′ | 0.040 | 0.117 | 85.0 | 100 |
| 7 | 1 gal. PD 544C—DDT Con.<br>8 gals. diesel oil | 100′ | 0.031 | 0.165 | 100 | 100 |
| 9 | 1 gal. PD 544C—DDT Con.<br>9 gals. diesel oil | 100′ | 0.026 | 0.132 | 98.5 | – |
| 14 | 1 gal. PD 544C—DDT Con.<br>9 gals. diesel oil | 100′ | 0.025 | 0.117 | 98.0 | – |
| 15 | 1 gal. PD 544C—DDT Con.<br>9 gals. diesel oil | 100′ | 0.025 | 0.117 | 100 | – |
| 10 | 0.4 lbs. DDT. per gal.<br>diesel oil | 100′ | 0.046 | 0.116 | 97.0 | – |
| 1 [1] | 1 gal. PD 544C—DDT Con.<br>1 gal. pure PD 544C<br>8 gals. diesel oil | 75′ | 0.069 | 0.403 | 55.0 | – |
| 8 | 9 gals. PD 544C—DDT<br>51 gals. diesel oil | 75′ | 0.055 | 0.214 | 99.5 | – |

[1] Disk from one nozzle missing; insecticide emitted as coarse drops.
[2] One gallon of PD 544C concentrate contains 1.71 lbs. DDT.

from 12.5 to 54.0 microns; the mean diameter for all studies was 29.5 microns. The number of droplets per square inch varied from 7 to 73 drops per study with the exception of study No. 9 which had 145 drops. Of these droplets, 75% were less than 10 microns in diameter.

Studies Nos. 6, 12, and 9 had 122%, 76% and 181% DDT recovery, respectively. Aside from these three studies, the percentage of DDT recovery varied between 9% to 52% with an average recovery of 23%. Excessively large recoveries may have been due to unusual microclimatic conditions which resulted in extra large amounts of the material being deposited on the slides. One excessively large drop on a slide could throw off the results. One droplet of 100 microns in diameter is equal by weight to 1000 droplets of 10 microns in diameter. Perhaps the main source of variation was that six floats with four slides each did not afford large enough sampling for the recovery test. Perhaps 10 or 12 floats with four slides on each would have given better samples and thus would have eliminated the source of sampling error.

*Recurrence of Anopheline Larvae in Rice Fields*

A study of the recurrence of anopheline larvae in treated rice fields was made. Six treated fields were observed at varying intervals of days up to at least 14 days. In two fields first instar larvae recurred within three days; in two fields the larvae recurred within five days; and in two fields the larvae recurred within six days. This indicated that there was no lasting effect from the airplane treatments.

The recurrence of anopheline larvae in one selected rice field treated on September 10 is graphically illustrated in Figure I. It brings out the fact that DDT aerosol treatments did not have any lasting effect. The number of first instar larvae continued to build up. The rate of development of the larvae seems to follow the mean daily temperature. From September 18 to September 22 there is a drop in the number of first instar larvae, and an increase of second and third instar larvae. Third and fourth instar larvae were more numerous as a result of normal larval development. The drop of first instar larvae on September 22 may be due to an earlier decline of the mean daily temperature on September 19. This drop in temperature may have retarded the incubation period of the eggs that were deposited, or else have limited the activities of ovipositing female mosquitoes.

On September 24th there was a very large increase in the number of first instar larvae and a corresponding increase in the fourth instar larvae. The increase in the first instar larvae appears to have followed a hot spell that occurred a few days earlier. There were a few early fourth instars at this time and if much more time were allowed to elapse, pupation would have occurred and adults would have emerged.

Under the existing temperature conditions prevalent in this area it seems advisable to treat the rice fields on the 10th day after the first treatment, to prevent an increase of pupae and subsequent adult emergence.

## V. COST OF PROGRAM

On the basis of the preceding results a total of 18,000 acres of rice fields were treated by the Sutter-Yuba Mosquito Abatement District at approximately one pint per acre of an oil solution containing 0.4 of a pound DDT per gallon.

Four solvents were used: A mixture of PD 554C and diesel oil, straight diesel oil, Standard Base Oil W.T. and Union Solvent. The latter two were free samples from the respective oil companies. However, in computing the cost of the treatment, the prices of these two solvents were included in order to determine what the total cost of operations would have been if the district had had to pay for these materials.

A breakdown of the total costs of operations is listed in Table 2 under three headings: Cost of materials, ground crew (wages of one man for six weeks), and hiring a pilot and renting a plane. The cost was thirty cents per acre, which is

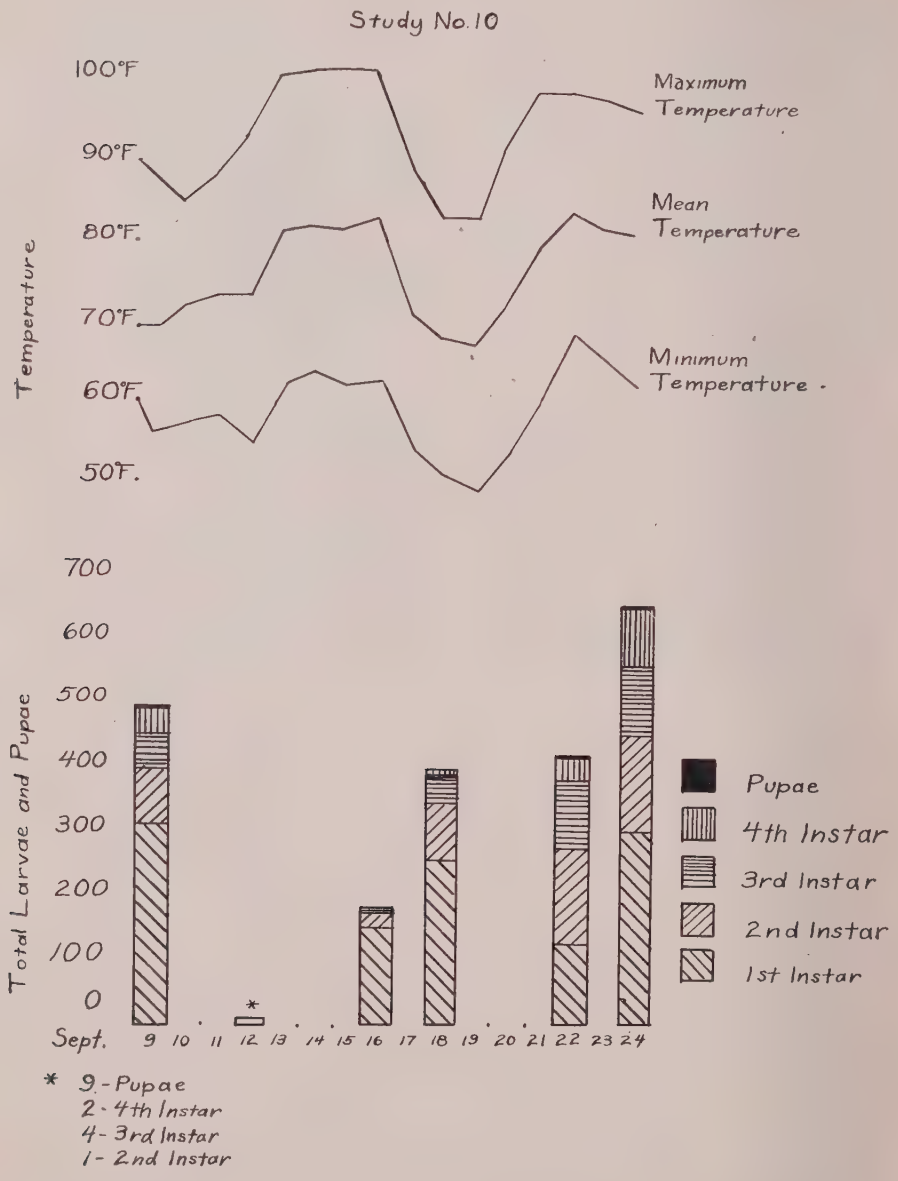


Figure 1. Recurrence of *Anopheles freeborni* Larvae in a Rice Field Following DDT-Airplane Treatment, Sutter-Yuba Mosquito Abatement District, 1947

considered to be economical for accomplishing mosquito control.

under temperature conditions prevailing in the Sutter-Yuba Mosquito Abatement District. Under the temperature conditions prevalent in the fall in this area, rice fields should be treated again by the 10th day after the first treatment.

TABLE 2.—Cost of Treating 18,000 Acres of Rice Fields by Airplane in the Sutter-Yuba Mosquito Abatement District.

September, 1947

| | | | | | |
|---|---|---|---|---|---|
| 1. *Material* | | | | | |
| PD 544C | — | 1000 gal. at 29¢ | — | $ 290.00 | |
| Diesel Oil | — | 3525 " " 8¢ | — | 280.00 | |
| Standard Base Oil W.T. | — | 100 " " 19¢ | — | 19.00 | |
| Union Solvent | — | 200 " " 17¢ | — | 34.00 | |
| Total | — | 4825 " " | — | 623.00 | |
| Pounds DDT Tech. Grade | — | 2260 lb. " 50¢ | — | 1,130.00 | |
| Total Cost of Material | | | — | | $1,753.00 |
| 2. *Ground Crew* at $200/mo. | | | — | | 350.00 |
| 3. *Total Flight Time* (74 hours at $45/hr.) | | | — | | 3,330.00 |
| GRAND TOTAL COST | | | | | $5,433.00 |

Cost per Acre — 30 Cents.

## VI. SUMMARY AND CONCLUSIONS

(1) The techniques and equipment developed by Krusé and Metcalf (1946) under the auspices of the Tennessee Valley Authority for the control of anopheline larvae using DDT as airplane thermal exhaust aerosols were applicable to the control of anopheline larvae in rice fields in the Sutter-Yuba Mosquito Abatement District.

(2) As little as 0.025 pounds of DDT per acre applied by this means gave 98% mortality of anopheline larvae.

(3) By flying at 25-foot heights resulting in at least a 100-foot effective swath, 98% control was obtained with a rate of one pint of insecticide which gave 0.025 pounds of DDT per acre. Flying less than 100-foot swaths was not economical.

(4) Variations of operational, meteorological, and biological factors did not appear to affect the results, as 96.5% control was obtained in all but the first three studies.

(5) There were not enough studies to warrant recommending the application of DDT for the control of *Culex* larvae, at the same dosage that was used for the successful control of anopheline larvae.

(6) Anopheline larvae recurred in rice fields within three days after treatment

(7) The control of anopheline larvae which were breeding in rice fields was economically accomplished by the airplane application of DDT applied in an aerosol produced from a thermal exhaust aerosol generator.

(8) More studies should be made in order: To determine the minimum lethal dosage of DDT applied as an aerosol with an airplane; to determine the effect of variations of operational, meteorological, and biological factors on anopheline larvae control when this method of DDT dispersal is used; to determine the number of thermal exhaust aerosol treatments that would be required in order to control recurring anopheline larvae following treatment.

ACKNOWLEDGMENT

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California, who visited the project and offered suggestions pertaining to the technical aspects of the project; and T. E. Hillis, Chemist, Division of Laboratories, California State Department of Public Health.

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# LARVICIDE TESTS ON BLACKFLIES IN NEW HAMPSHIRE [1]

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In the summer of 1947 tests were made to evaluate several compounds as larvicides for blackflies breeding in streams in the White Mountains of New Hampshire. A material was sought which would control these insects but would be harmless to the fish population.

Little published information on this subject has been noted. O'Kane (1926) used oils of a soluble or miscible type, and these were effective under some conditions but were injurious to trout at dosages necessary to control larvae. Fairchild and Barreda (1945) found DDT effective against larvae in streams of Guatemala when applied as an emulsion at 0.1 p.p.m. Garnham and McMahon (1947) reported the eradication of simuliid larvae from an area in Kenya Colony, East Africa, with DDT dosages of 1.3 to 35.6 p.p.m.

In New Hampshire pyrethrum, DDT, benzene hexachloride, TDE, chlordan, caustic soda, and chlorinated lime were first tested in flumes at different dosages. The three most effective of these materials —TDE, DDT, and benzene hexachloride —were then tested under natural conditions in streams.

*Procedure.*—Flumes, or troughs, 6 feet long, lined with metal and water-proofed with shellac, were used for the preliminary tests with measured dosages of larvicides. The ends of the flumes were covered with fine-mesh wire. The flumes were placed in stream rapids so that a constant flow of water was maintained through them. Blackfly larvae attached to blades of grass were placed in the current. The larvicides were introduced into the flumes from a drip funnel gaged to deliver 1,000 cc. over a 10-minute interval. The desired dosages of toxic agent were obtained by varying the concentration of the solution or emulsion. At intervals of 10, 30 and 60 minutes counts were made of the detached larvae and of the normal larvae that remained attached to the blades of grass. Control counts were made of larvae subjected to the same handling in the flumes except that water alone, or acetone solvent alone, was added through the drip funnel.

In the stream tests pretreatment counts of the larval population on marked rocks and blades of grass were made in measured sections of a stream. The larvicides were introduced at the upper end of the test area during a 10-minute period, and posttreatment counts were made 1 or 1½

[1] This work was conducted under a transfer of funds, from the Office of the Surgeon General, Department of the Army, and, in part, from the Bureau of Medicine and Surgery, Department of the Navy, to the Bureau of Entomology and Plant Quarantine.

[2] The work was carried out under the supervision of C. C. Deonier.

hours afterwards. A 24-hour check was made in two of the tests. The rates of flow of the streams were measured to determine the amount of material to be used.

It has been observed in these and in other tests that the blackfly larvae release themselves from their site of attachment within a short time after they are exposed to larvicides in their natural habitats. Evidently they are swept downstream by the current, but their ultimate fate has not been determined.

*Results of Flume Tests.*—Data obtained in these tests, on larvae of *Simulium venustum* Say, are shown in Table 1. DDT required a dosage of 1 p.p.m. and benzene

TABLE 1.—Flume tests in which the blackflies *Simulium venustum* were exposed for 10 minutes to larvicides in colloidal suspensions.

| Material | Dosage (p.p.m.) | Number of larvae placed in flume | Percentage of larvae detached after 10 minutes | 30 minutes | 60 minutes |
|---|---|---|---|---|---|
| Pyrethrins | 0.033 | 68 | 35 | 46 (23) [1] | – |
| | | 42 | 45 | 62 (10) | – |
| | | 69 | 30 | 57 (17) | – |
| | | 78 | 27 | 46 (20) | – |
| | | 80 | 35 | 61 (39) | – |
| | .01 | 31 | 26 | 45 (29) | – |
| | .33 | 82 | 26 | 48 (16) | – |
| | | 49 | 43 | 67 (33) | – |
| | | 37 | 30 | 49 (32) | – |
| | .5 | 44 | 34 | 64 (34) | – |
| | 0 (control) | 50 | 0 | 2 | – |
| DDT | .05 | Small 22 | 0 | 14 | 95 |
| | | Large 26 | 0 | 0 | 27 |
| | .1 | Small 35 | 9 | 48 | – |
| | | Large 5 | 0 | 0 | – |
| | | Small 40 | 7 | 25 | 42 |
| | | Large 7 | 14 | 14 | 14 |
| | .2 | Small 50 | 8 | 44 | 88 |
| | | Large 9 | 0 | 0 | 44 |
| | 1.0 | Small 56 | 23 | 61 | 100 |
| | | Large 23 | 9 | 57 | 96 |
| | 0 (control) | 48 | – | 8 | 0 |
| | | 47 | – | 8 | 8 |
| TDE | .033 | Small 39 | 28 | 67 | 82 |
| | | Large 27 | 7 | 15 | 19 |
| | .05 | Small 48 | 54 | 93 | – |
| | | Large 2 | 100 | 100 | – |
| | | Small 28 | 46 | 96 | 100 |
| | | Large 8 | 12 | 50 | 87 |
| | .10 | Small 27 | 33 | 78 | 81 |
| | | Large 11 | 18 | 27 | 36 |
| | | Small 47 | 26 | 63 | 85 |
| | | Large 10 | 10 | 10 | 20 |
| | .20 | Small 40 | 80 | 90 | 100 |
| | | Large 3 | 33 | 100 | 100 |
| | | Small 35 | 80 | 97 | 100 |
| | | Large 10 | 50 | 60 | 100 |
| | .5 | Small 47 | 83 | 89 | 98 |
| | | Large 7 | 57 | 100 | 100 |
| | | Small 41 | 83 | 93 | 100 |
| | | Large 9 | 33 | 78 | 100 |
| | 1.0 | Small 38 | 92 | 100 | 100 |
| | | Large 20 | 60 | 100 | 100 |
| | 0 (control) | 57 | – | – | 12 |
| | | 49 | – | – | 8 |

| Material | Dosage (p.p.m.) | Number of larvae placed in flume | Percentage of larvae detached after 10 minutes | 30 minutes | 60 minutes |
|---|---|---|---|---|---|
| Benzene hexachloride (12 percent gamma isomer) | 0.2 | Small 34 | 6 | 59 | – |
| | | Large 17 | 0 | 0 | – |
| | 0.5 | Small 89 | 15 | 69 | 85 |
| | | Large 6 | 17 | 33 | 33 |
| | 1.0 | Small 48 | 15 | 54 | 92 |
| | | Large 1 | 0 | 0 | 0 |
| | 2.0 | Small 38 | 53 | 100 | 100 |
| | | Large 2 | 60 | 100 | 100 |
| | 0 (control) | 27 | – | 0 | 4 |
| | | 45 | – | 4 | 9 |
| Chlordan | 1 | Small 29 | 7 | 14 | – |
| | | Large 13 | 0 | 0 | – |
| | 2 | Small 23 | 17 | 26 | 65 |
| | | Large 8 | 0 | 0 | 12 |
| | 4 | Small 33 | 55 | 67 | 91 |
| | | Large 5 | 20 | 60 | 80 |
| | 0 (control) | 47 | – | 6 | 11 |
| | | 35 | – | 6 | 11 |
| Acetone alone | 100 | 47 | 0 | 0 | – |
| | 100 | 57 | 4 | 4 | – |
| | 1000 | 51 | 0 | 0 | – |
| | 5000 | 64 | 45 | 45 | – |

[1] Percentages of larvae noticeably affected but not detached are shown in parentheses.

hexachloride 2 p.p.m. to cause the detachment of all larvae within 60 minutes. Chlordan did not cause 100 per cent detachment at 4 p.p.m. The 60-minute observation period was probably too short to show accurately the full effect of these compounds. TDE caused all the larvae to detach in 60 minutes at only 0.2 p.p.m., and therefore appeared to be about 5 times as effective as DDT and 10 times as toxic as benzene hexachloride. Large larvae were more resistant to the materials than the small ones.

Pyrethrum caused some of the larvae to detach, but others, although visibly affected, remained on the grass blades and assumed a characteristic looped position. They appeared to attach themselves by silk secretion, and whether or not they subsequently recovered was not determined. For this reason the effectiveness of pyrethrum was difficult to determine. The percentages of detached larvae were about the same at all dosages. In two additional tests (not shown in the table) piperonyl cyclonene was added at the rate of 10 p.p.m., but it did not increase the effect of the pyrethrum noticeably.

Sodium hydroxide and chlorinated lime were also tested to determine whether their irritating effect might be sufficient to cause the larvae to detach. They were not completely effective at high dosages.

*Results of Stream Tests.*—DDT, TDE, and technical benzene hexachloride (12 per cent gamma isomer) were tested in 200-foot sections of streams heavily infested with larvae of *Simulium venustum* and smaller numbers of *Prosimulium hirtipes* Fries. The materials were applied in emulsions containing kerosene and *Triton X-100* (an aralkyl polyether alcohol). In two tests with TDE at 0.2 p.p.m. all the larvae were eliminated, and in one test at 0.05 p.p.m. less than 1 per cent of the larvae remained after treatment. The other two compounds gave almost complete control in one test each at 0.2 p.p.m.

The data are summarized in Table 2.

In another test TDE was similarly applied at intervals of 1 mile over a 5-mile section of one stream. Larval counts were made over a distance of 200 feet near the end of each mile section. About 1½ hours at 1 p.p.m.; at 2 p.p.m. all the small fish were severely affected, and at 3 p.p.m. the larger fish were also affected. All of these fish recovered within a few hours. At 5 p.p.m. 4 fish were killed and 12 others were severely affected but recovered later.

TABLE 2.—Stream tests on blackfly larvae with three compounds.

| Material | Dosage (p.p.m.) | | Larvae counted before treatment | Interval (hours) | Per cent reduction |
|---|---|---|---|---|---|
| | | 200-foot stream section | | | |
| TDE | 0.05 | | 6490 | 1 | 99.6 |
| | | | | 24 | 99.5 |
| | .2 | | 369 | 1 | 100 |
| | | | 5000 | 1½ | 100 [1] |
| DDT | .2 | | 2002 | 1 | 97.6 |
| | | | | 24 | 99.8 |
| Benzene hexachloride (12 per cent gamma isomer) | .2 | | 3500 | 1 to 1½ | 99.1 |
| | | Five-mile stream section | | | |
| TDE | 0.2 | 1st mile | 2304 | About 1½ | 98.8 |
| | | 2nd mile | 1376 | 1½ | 95.8 |
| | | 3rd mile | 1566 | 1½ | 99.3 |
| | | 4th mile | 1304 | 1½ | 100 |
| | | 5th mile | 27 | 1½ | 100 |
| | | Total | 6577 | | 98.6 |

[1] One large larva found a quarter mile below the point of application.

after treatment (Table 2) no larvae were found in the lower 2 miles of the area, and the control over the entire 5-mile section was 98.6 per cent.

*Tests on Fish.*—Preliminary tests were conducted to determine the relative toxicity of TDE and DDT to brook trout, *Salvelinus fontinalis,* and rainbow trout, *Salmo* sp., furnished by the State Game and Fish Commission from rearing ponds at Whitefield, N. H. A pen for holding the fish was constructed of quarter-inch mesh wire in the outlet stream from the rearing ponds. The compounds in emulsion form were applied above the pen in the same manner as in the larvicide tests.

TDE at 1, 1.5 and 5 p.p.m. had no noticeable effect on the fish. With DDT one of the small fish was slightly affected

*Summary.*—In flume tests on larvae of the blackfly *Simulium venustum* Say, a suspension of TDE caused the detachment from blades of grass of all larvae within 60 minutes at a dosage of 0.2 p.p.m. At this strength it was indicated to be about 5 times more toxic than DDT and 10 times more toxic than benzene hexachloride. Chlordan did not cause 100 per cent detachment at 4 p.p.m. Pyrethrum at low dosages affected the larvae, but caused only a part of them to detach.

In stream tests the larvae were almost completely cleared from 200-foot sections of the streams within 1½ hours after 10-minute applications of emulsions of TDE were applied at 0.05 p.p.m. and DDT and benzene hexachloride at 0.2 p.p.m. TDE was completely effective at 0.2 p.p.m. At

this dosage also, applications of TDE at intervals of 1 mile over a 5-mile section of one stream gave 98.6 per cent control.

TDE was apparently much less toxic than DDT to rainbow and brook trout, having no noticeable effect on those exposed for short periods to applications in emulsion form up to 5 p.p.m. With DDT at this dosage, 4 of 16 trout were killed and the others were severely affected. Severe temporary effects on fish exposed to dosages of 2 and 3 p.p.m. were also observed.

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# REARING OF *ANOPHELES QUADRIMACULATUS* SAY AND *AEDES AEGYPTI* (L.) IN THE LABORATORY [1]

A. H. CASANGES, E. R. MCGOVRAN, AND J. V. CHILES
United States Department of Agriculture, Agricultural Research Administration, Bureau of Entomology and Plant Quarantine

The importance of *Anopheles quadrimaculatus* Say as a common vector of malaria has caused many workers to try to rear this species. The purpose of this paper is to give a simple practical method of rearing this species under laboratory conditions. Directions are also given for rearing *Aedes aegypti* (L.).

## *Anopheles Quadrimaculatus*

The original culture of *Anopheles quadrimaculatus* maintained at the Bureau of Entomology and Plant Quarantine laboratory, Agricultural Research Center, Beltsville, Md., was obtained through the courtesy of Walter Reed Medical Center, Washington, D. C. This culture was producing a maximum of 100 adults a day, but as more work was to be done with this species it was necessary to increase the culture to produce a maximum of 5,000 adults a day. Several shipments of eggs were made from the Orlando, Fla., laboratory of the Bureau of Entomology and Plant Quarantine. Three shipments were made from the Tennessee Valley Authority, one lot was received from the United States Public Health Service, and numerous shipments extending over a period of three months were received from a commercial concern. As a result of this increase there was always a surplus of eggs for experimental use.

More than a hundred methods and techniques [2] using various foods and media were tested in this laboratory. The method that was evolved as a result of these tests produces from 3,000 to 5,000 pupae a day. This method has been used for 3 years and has proved very efficient.

## TREATMENT OF EGGS

White-enamel pans 8 inches in diameter are used for oviposition. They are filled two-thirds full of pond water,[3] and on the

[1] This work was financed partly by a transfer of funds recommended by the Committee of Medical Research, from the Office of Scientific Research and Development to the Bureau of Entomology and Plant Quarantine, and partly by a transfer of funds from the Office of the Quartermaster General to the Bureau of Entomology and Plant Quarantine.

[2] The authors wish to thank M. F. Schott and Norman Moskowitz for their help in making many of these tests.

[3] The pond is an abandoned iron mine that is fed by springs and has a slight run-off. It has about 1 acre of surface.

inside of each is a 2-inch strip of paper toweling placed near the top and extending 1 inch below the water surface. This paper prevents the eggs from sticking to the side of the pan and also keeps them moist if water evaporates.

Pans for oviposition are put in the stock cages every day. The pans containing eggs are removed and kept in a constant temperature room at 25° C. until the eggs hatch, which takes about 48 hours.

### Treatment of Larvae

The larvae are reared in white-enamel photographic trays 17 by 14 by 3 inches, which are kept on a rack (fig. 1). As larvae seem to prefer darkness, the trays are kept covered with pieces of masonite. These covers also eliminate drafts, which tend to disturb the larvae, keep out dust, and provide support where it is necessary to stack the trays.

Each tray is cleaned with a solution of sulfuric acid and sodium dichromate and then thoroughly rinsed with water before it is used.

By maintaining a temperature of 27° C. in the rearing room it is possible to keep the temperature of the rearing medium at not less than 25°, which seems to be favorable to growth.

The newly hatched larvae are transferred by means of a medicine dropper to the rearing trays, approximately 500 larvae to a tray. Each tray contains 2.5 liters of distilled water, 50 mg. of brain-heart infusion, and 50 mg. of pure dry brewers' yeast. The trays are then placed in the rack and the contents allowed to settle before the larvae are fed. The larvae are fed a high-grade dog food, which is ground through a corn grinder and then further pulverized in a ball mill for 36 hours. They are fed once the first day and twice each day thereafter except Sundays. The amount of dog food to be given each tray

Fig. 1.—Rack holding photographic trays and oviposition pans. Shelves to the left hold battery jars containing *Aedes aegypti*.

of larvae varies with the number and size of the larvae. A tray of 500 first-instar larvae takes about 40 to 50 mg. at each feeding when the temperature of the medium is 25° C., whereas 500 fourth-instar larvae under the same conditions take about 1.1 to 1.2 grams. A series of experiments showed that feeding the larvae twice a day and omitting Sunday feedings gave satisfactory results.

Before each feeding the surface of the medium is washed with distilled water to remove any old food or dust and also to replace the water lost by evaporation. The medium tends to darken, and by the time larvae have reached the fourth instar is of a dark brown color although there is no trace of scum. There is a slightly sweet odor to the medium. By this method 64 per cent of the larvae pupated in 11 days and 96 per cent in 15 days.

### TREATMENT OF PUPAE

The pupae are collected every day except Sunday. To collect the pupae in trays in which the larvae have just started to pupate, or where there are only a few pupae and many larvae, a 25-ml. pipette with a rubber tube is used. In trays in which about two-thirds of the larvae have pupated, the contents are poured through a strainer lined with gauze, and the pupae

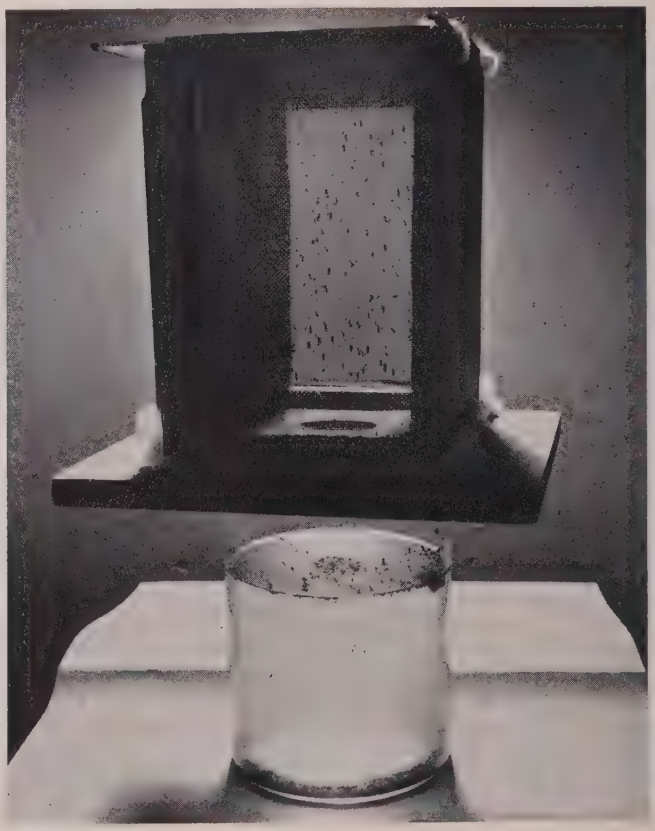


FIG. 2.—Pupae in battery jar, and cage containing adult mosquitoes that have just emerged.

and larvae then washed from the gauze into clean water.

The pupae to be used for testing are put in 6-inch round battery jars, about 1,500 to 2,000 to a jar, and allowed to emerge into small cages which are placed over the jars (fig. 2). The pupae to be used for stock are kept in small pans, which are placed in the stock cage.

It is important that the pupae be in clean water to prevent emerging adults from getting caught in the media and drowning.

The adults emerge in about 36 hours when the temperature is between 25° and 27° C. The emergence has been between 95 and 100 per cent of the pupae.

### Treatment of Adults

The adults are kept in a room where the temperature is constant at 27° C. and the relative humidity is between 80 and 85 per cent. The room is darkened for a part of the day, as mosquitoes feed better in the dark.

Wooden cages 22 by 36 by 24 inches, covered with cheesecloth and having two sleeve openings in front with a celluloid window between the openings, are used for breeding cages (fig. 3).

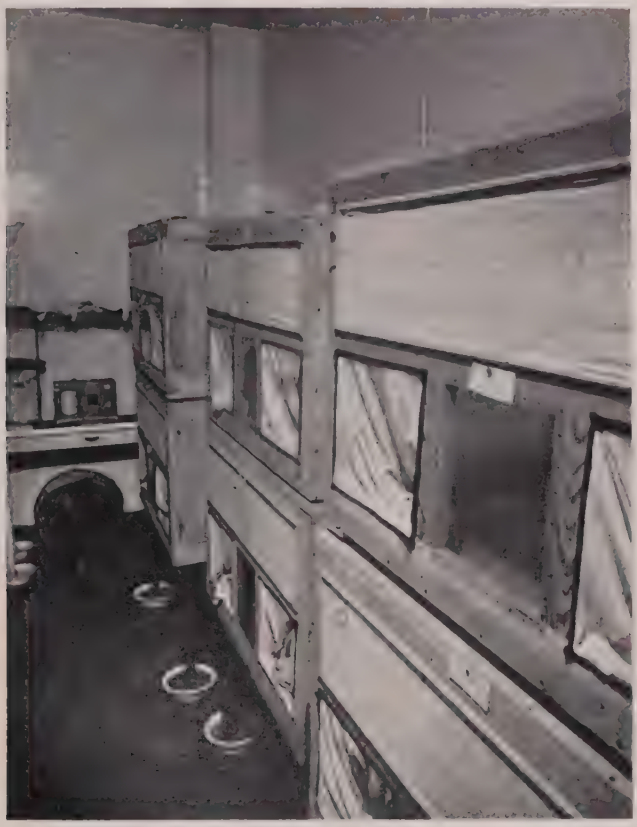


Fig. 3.—Cages for breeding *Anopheles quadrimaculatus* and *Aedes aegypti* mosquitoes. *A. aegypti* eggs are being dried on rack and stored in jar on table.

Three cages are stocked in rotation, one each week, with from 3,000 to 5,000 pupae. No pupae are added to a cage for 3 weeks. At the end of this time the cage is cleaned thoroughly and then restocked. By having three cages and stocking one each week, two cages of mosquitoes are always producing well.

Raisins and a slice of apple are placed in petri dishes on the floor of the cage, and cotton saturated in a 10-per cent sugar solution hung from the top are kept in the cage at all times.

About the third day and every day thereafter a blood meal is offered the mosquitoes. Guinea pigs are used for this purpose. They are held in small metal cages with removable trays and bands small enough to prevent the pigs from turning around (fig. 4). Each pig is left in a cage from 2 to 3 hours. The backs of the guinea pigs are shaved about once a week.

### *Aedes aegypti*

*Aedes aegypti* is a satisfactory insect to rear in the laboratory because it requires a minimum of care. The supply of these mosquitoes can be controlled to meet the demand, as the eggs may be kept at least 6 months if stored at a constant temperature of 25° C. and a relative humidity of about 85 per cent, and where there is good ventilation.

A rack with 6 shelves holding 42 battery jars is used for rearing *aegypti* larvae.

#### Treatment of Eggs

The eggs of this species will not hatch until they have dried for several days and are then soaked for 24 hours.

An 8-inch pan is covered with a paper towel that has been dipped in pond water. Enough water is placed in the pan to prevent the paper from becoming dry. One pan is placed in each stock cage, and after 24 hours it is replaced by another pan. The towel on which the eggs have been deposited is taken from the pan and placed on a dry towel or a rack to dry. When the eggs are dry, they are stored in a jar in the constant-temperature room. As larvae are needed, these towels containing the eggs are soaked in pond water for 24 hours (about half of the eggs should hatch) and then removed, dried, and again stored pending further use (fig. 5).

The larvae are fed whole-wheat bread from which the crust has been removed. It is sliced and each slice is cut into 16 pieces, dried in an oven, and stored until

#### Feeding

Approximately 2,000 young larvae are put in a battery jar containing 2 liters of pond water. About 50 mg. of brain-heart infusion, 50 mg. of powdered brewers' yeast, and a piece of whole-wheat bread are added. The jar is then covered with cheesecloth. The amount of food is increased as the larvae grow older. The jars are inspected each day; if any food is left, no more is added, as it is important not to leave food in the jar long enough to decay.

The larvae pupate in from 6 to 10 days. When most of the larvae have pupated, the contents of the jar are strained through gauze and the pupae put in distilled water to emerge.

The emergence cages are similar to those used for *Anopheles quadrimaculatus* (fig. 3).

*Aedes aegypti* adults are handled and fed in the manner described for *Anopheles quadrimaculatus*.

#### Collecting Mosquitoes in the Laboratory

Each day a hand vacuum cleaner is used to collect any loose mosquitoes in the laboratory, as well as adults that may have emerged in trays or jars.

Fig. 4.—Showing the plaster egg and cage used to hold it

Fig. 5.—Removing the egg papers which have been soaked.

# NEWS AND NOTES

AS EXPLAINED IN OUR JUNE NUMBER, HARRY H. STAGE HAS BEEN "DOING" AFRICA. On June 16, he wrote from Kenya. He had visited Tanganyjka and Nyasaland, and was including Uganda, Mauritius, and Cairo in future plans. In his inimitable way, Harry said: "It is a good thing they selected a young man to go on this expedition" . . . "I'm on the go fully 25 hours a day. For example, yesterday, I was in a truck from 7:30 A.M. until 8:30 P.M., covering 200 miles of the most gosh-awful road you can imagine—just like a washboard and full of curves, ups and downs, and me straining every eye to see one more rhino, giraffe, or what have you. I did see them, too, and the tsetse" . . . Harry returned to New York, July 26, on the Queen Mary.

DR. S. P. RAMAKRISHNAN, ASSISTANT DIRECTOR, MALARIA INSTITUTE OF INDIA, is visiting the United States under the auspices of the World Health Organization. He is interested in all phases of malaria control and of mosquito transmission of diseases. In July, he visited the National Institutes of Health, Bethesda, Md., where he joined the AMCA. During the next 8 months while he is in the United States, Dr. Ramakrishnan may be greeted not only as a fellow AMCA member but as a fellow Rotarian (he belongs to the Coonoor, India, group) by many of our control experts.

H. L. T.

WE DROVE DOWN TO BLACKSBURG, SOUTH CAROLINA, FOR THE WEDDING. Louise (Goode) was a lovely June bride—complete with satin gown, calla lilies, and a tall, handsome groom, John R. Scoggins. A full southern moon shone down so softly on the festivities amidst blossoming magnolias, and the air was so heady with the scent of cape jasmine, that even your Associate Editor became starry-eyed. Not one mosquito appeared.

H. L. T.

A NEW WEAPON TO KEEP DOWN MOSQUITO POPULATIONS in shore areas was the featured attraction at a demonstration held in Clinton, Conn. on May 20 for mosquito control men from the Northeast. The weapon is a salt marsh ditch cleaning device, developed by R. C. Botsford, superintendent of the Connecticut State Board of Mosquito Control. The demonstration was sponsored by the American Mosquito Control Association for its members in the Northeast. The machine is compact and light enough for easy handling in small salt meadows and does as efficient a job as the larger type machine in large marshes at less expense and with less breakage.

Mr. Botsford calls his invention a "scavel." The digging part is a single steel welded unit with no moving parts, which is attached to the loading arms of a caterpillar tractor. In construction, it resembles a mouldboard plough with a tongue which is shaped like the cross-section of a ditch. The tongue scoops the mud and grass from the ditch while fan-shaped skids on the sides force the debris back to the bank. Wooden cleats attached to the regular steel tractor treads for support spread the debris flat along the sides of the ditch.

The scavel can be constructed for $350; with the tractor, the cost comes to about $3,000. The type of machine now being used in large marshes costs approximately $7,000.—Release from Conn. Agric. Expt. Sta., dated May 20, 1949.

Effective clearage shows plainly in the wake of the tractor-driven "plough." Note how tractor treads crush debris flat along the bank, eliminating danger of reclogging. The apparatus cleans ditches 30 times as fast as with hand labor which, up to this year, was used for all salt marsh ditching work in Connecticut.

New salt marsh ditch cleaner, developed by R. C. Botsford, superintendent of the State Board of Mosquito Control, attacks a clogged ditch in a Connecticut marsh which, left uncleared, would make an excellent breeding place for mosquitoes.

PASB ADDS WHO REGIONAL OFFICE DUTIES.—On April 27, 1949, Uruguay became the four

teenth country in the Western Hemisphere to ratify the Constitution of the World Health Organization. The other countries which have already ratified the Constitution are: Argentina, Brazil, Costa Rica, Chile, the Dominican Republic, Ecuador, El Salvador, Haiti, Honduras, Mexico, Paraguay, the United States and Venezuela.

With 14 of its 21 member nations in WHO, the Pan American Sanitary Organization was empowered to authorize a permanent agreement with the World Health Organization to become the Regional Office for WHO in this hemisphere. On May 24, Dr. Brock Chisholm of WHO and Dr. Fred L. Soper of the Pan American Sanitary Bureau signed the agreement for that purpose, thus consolidating two of the most important international organizations for western hemisphere operations in public health. This step brings the operations of these two organizations under one office with Dr. Soper as director in preparation for a concerted attack on public health problems throughout the Americas.

This will be of real interest to many of our members because the Pan American Sanitary Bureau has for several years been especially active in anti-malaria and *Aedes aegypti* eradication programs of the American countries and WHO has adopted as one of its major objectives the promotion of malaria eradication. Extensive programs for the eradication of malaria in the Western Hemisphere are under consideration through these coordinated efforts.

RALPH J. VANDERWERKER

PERRY W. RUTH AND THE AMCA FIGURED PROMINENTLY IN NEWS STORIES in two of Norfolk's leading papers, the "Norfolk Virginian-Pilot," and the "Norfolk Ledger-Dispatch." The "Virginian-Pilot" for May 29 stated:

"Perry W. Ruth, secretary and technical advisor of the Norfolk Mosquito Commission, has been appointed chairman of the Advisory Board of the Virginia Mosquito Control Association and chairman of two program committees that will arrange for a joint meeting of the association with the American Mosquito Control Association at the Cavalier Hotel, February 23 and 24.

"Announcement of Ruth's advisory appointment came yesterday from Stuart M. Gibson, of Hampton, president of the State association.

"The other members of the board are Rear Adm. Carl A. Broadus, USN, medical officer of the Fifth Naval District; Col. Edward M. Fickett, USA, post commander of Fort Monroe; George W. Price, of Norfolk; Judge Floyd E. Kellam, of Princess Anne County, and James W. Roberts, of Norfolk." H. L. T.

"TOMMY" MULHERN, WHO AFTER MORE THAN 20 YEARS of mosquito control work in New Jersey, is leaving to take over a vector control post in California, was honored August 22 by his associates. A farewell testimonial luncheon was given at the Roger Smith Hotel in New Brunswick. About 50 persons were present as State and County officials expressed appreciation of Mulhern's services.

Harry Stage, commenting on the occasion, said: "Tommy received $250 in bonds, a plate with mosquitoes and his name in gold, and a gold fountain pen. I was glad to be there."

A. Paul King, Editor of "New Jersey Counties" magazine and toastmaster at the luncheon, paid tribute in the September 1949 issue with an article entitled, "Man with a Mission . . . to Kill Mosquitoes." Mulhern's career is outlined from the time he, as a high school student and pupil of Dr. Thomas J. Headlee, served as an inspector during the summers of 1925, 26, and 27.

Now that he is taking up duties 3,000 miles away in the San Joaquin Valley of California, the entire AMCA adds its wishes to that of King who wrote in his send-off: "Tommy Mulhern carries with him to his new opportunity in California the heartfelt appreciation of hundreds of County officials of the several Boards of Chosen Freeholders from New Jersey as he embarks upon an even greater career in mosquito control."

## CORRECTION!

Refer to the note on "Yellow Fever in Panama" on page 72 in MOSQUITO NEWS, Vol. 9 No. 2 (June 1949) by F. C. Bishopp.

Dr. Bishopp has requested that the last sentence of his note should be amended to read "This was the jungle type of yellow fever and is probably transmitted by some species of *Haemagogus*."

Dr. Bishopp, in his letter requesting this correction, stated that the name *spegazzini* which appeared in his original source of information, was not checked until Dr. Komp returned from Panama and called attention to the fact that this particular species is rare, if it occurs at all, in the locality where the jungle yellow fever occurred.

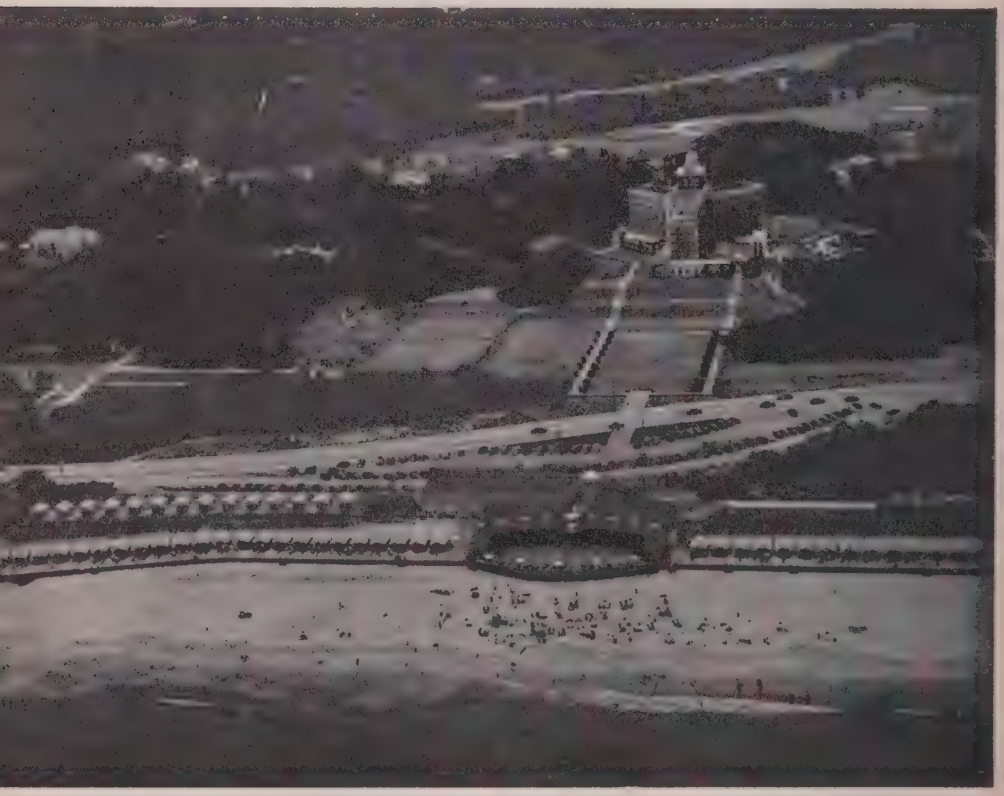
# ASSOCIATION NEWS

## JOINT MEETING OF THE AMERICAN AND VIRGINIA ASSOCIATIONS

Have you ever been to Virginia Beach in February? Well, this coming February you will have a good reason to go, because the American Mosquito Control Association and the Virginia Mosquito Control Association are meeting jointly on February 22, 23, and 24 at the Cavalier Hotel at Virginia Beach, near Norfolk, Virginia.

The mean temperature for February at Virginia Beach is 41.4 degrees. In the past thirteen years there has been only one rainy or unpleasant Washington's birthday. In 1945, the temperature was 75 degrees on February 22. Of course, perfect weather cannot be guaranteed, but it is a better than an even bet based on past records that it will be cool and clear.

Bring your golf clubs, for two championship courses will be in perfect condition waiting for duffers and the experts alike. And, horseback riding through many miles of woodland trails will be in the offering. If you are a member of the



Aerial View of Cavalier Hotel and Beach Club

polar bear club, you can swim in the ocean; but if you're just an ordinary person, you can get your dip in the luxurious glass enclosed pool at the Cavalier.

And speaking of the Cavalier, it is one of the really fine hotels in the country. It is situated on a 250-acre estate overlooking the Atlantic Ocean. Its southern cooking and service is not to be surpassed anywhere. The management has quoted the convention a special rate of $10.00 per day single and $19.00 per day double, American plan.

Tidewater Virginia is really rich in American history. Within a few miles of Virginia Beach was established the first English settlement in America; the Revolutionary War ended at Yorktown, the Monitor and the Merrimac fought in the waters of Hampton Roads, and many other important events of history happened in this section of the Commonwealth. Of additional interest, a twenty mile drive places one in the City of Norfolk, the site of one of the world's largest naval bases.

Of course, there will be meetings. These will be held in the comfortable convention rooms at the Cavalier. The program calls for registration and hospitality hour on the afternoon and evening of the twenty-second, and on the morning, afternoon, and evening of the twenty-third and twenty-fourth there will be meetings and special entertainment concluding with a banquet, floor show and dance on the twenty-fourth.

Those who wish to be included will start on a cavalcade on Saturday morning on the twenty-fifth taking in the mosquito control and points of interest in the Hampton Roads area, spending the night in Williamsburg, Virginia. On the twenty-sixth, the party will proceed to Wakefield, Virginia, the birthplace of George Washington, then to Annapolis, Maryland, and finally spend the night at Rehoboth Beach, Delaware. On the twenty-seventh, an inspection of mosquito work in Delaware will be in the offering, finishing up at Cape May, New Jersey. The following day will include an inspection of mosquito control operations in south Jersey finishing up at Atlantic City in time to attend the New Jersey Mosquito Extermination Association meetings to be held the following several days. PERRY W. RUTH

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Mr. Rowland E. Dorer, as chairman of the Arrangements Committee, has sent in a tentative program for the cavalcade and meetings, but inasmuch as there may still be minor changes, most of the details will be saved for the December number of the NEWS. Points not mentioned in Mr. Ruth's invitation include a trip to the National Institutes of Health, Naval Medical Center and Beltsville Experiment Station of the U. S. Dept. of Agriculture, on February 21, and a special inspection trip of mosquito control operations in North Jersey, and Long Island, New York. Anyone wishing further information should write to Mr. Rowland E. Dorer, Chairman Arrangements Committee, Room 203, Essex Bldg., Norfolk, Virginia.

MAKE YOUR PLANS NOW!

# EDITORIAL SECTION

Under *Association News* is printed a most attractive invitation sent in by Perry W. Ruth to attend the meetings of the American Mosquito Control Association and the Virginia Mosquito Control Association, to be held in February at Virginia Beach.

In the same section is presented a tentative program for these meetings submitted by Mr. Dorer. Although many details are necessarily lacking at this early date, this glimpse of the plans being made is sufficient to promise a most interesting meeting, or rather, series of meetings. The privilege of attending both the Virginia meetings and the New Jersey meetings on the same trip makes the entire program especially attractive.

The acting editor cannot forego this opportunity to call attention to one of his perennial difficulties: "to hold or not to hold, that is the question." The dummy of the September number was ready to go to the printer (almost on time, in spite of staff vacations, and the usual rush of summer field work) when the last notices of the forthcoming meetings came to the desk. Although they were not sent in specifically for printing in the September number, it seemed appropriate to include them, especially since the information presented might help members to decide whether they would attend. The delay occasioned in this instance by submitting new material at a late date seemed entirely justified.

On the other hand, papers, notices and miscellaneous information which could have been sent in at an early date, but which are received later than the middle of the month preceding the month in which a given issue is to be published, cannot usually be included, unless the schedule has been upset or is upset for some other cause beyond the control of the printers or editor.

Admittedly, the editors have been somewhat at fault in the past in permitting the deadline to be too flexible. The printer has a number of other journals on the presses at the same time as MOSQUITO NEWS, and has to set up a schedule for them. If the material for MOSQUITO NEWS is not on hand at the proper time, one of the other jobs may be started, and result in a delay not, sometimes, of a day or two, but of a week or more before work on MOSQUITO NEWS can continue.

*All contributions should be in the editorial office at least six weeks before the scheduled publication dates, that is, about the middle of the month preceding the month of publication.*

# REVIEWS AND ABSTRACTS

The Natural History of Mosquitoes. By Marston Bates. 379 pp., 9 figures, 16 plates. The MacMillan Company, 1949. $5.00.

Through the author's repeated and effective reference to the value of mosquitoes as experimental animals, entirely aside from their economic importance, the reader became convinced that entomologists and zoologists have missed many opportunities to gather basic physiological information.

There is no question that by far the major efforts of nearly all those who have studied mosquitoes have been directed toward practical ends. Certainly we cannot severely criticize those who have had their research dominated by a desire to destroy mosquitoes as annoying pests or as vectors of the scourges of man. Perhaps the trouble is that too few of those engaged in so called pure science have realized the fitness of the mosquito as a subject for fundamental studies of animal habits, responses, general physiology and interorganism relations. The author has pointed out numerous gaps in our knowledge of mosquitoes, and opportunities for students of animal behavior to make contributions to pure science and at the same time provide sounder basic facts upon which to proceed with the war on mosquitoes that is being so vigorously pursued.

It is stated in the preface that much of the voluminous "literature on mosquitoes is an uncritical accumulation of facts that were easy to record, or facts that were related to some momentarily fashionable subject of study or of facts that were needed for the attainment of some immediately practical objective." With this we agree only in part as there have been numerous contributions that are more than an "uncritical accumulation of facts."

The author states "The pile of facts about mosquitoes is an impressive accumulation, one that should be useful to all biologists if only the assortment were a little better organized." He then sets about organizing these facts in the present volume. In this he has succeeded well although some important biological information is conspicuous by its omission.

In the author's words, "The first part of the book is organized around the life history of the mosquito, taking up in turn the characteristics of behavior, physiology, and environmental relations of the adult, egg, larval, and pupal stages. Considerable space is devoted to the relations between mosquitoes and other organisms, especially to the vector relationship with plasmodia and viruses, since this relationship has been the subject of a great deal of study. Here again I have tried to stress differences among mosquito species, since differences in susceptibility to pathogens provide valuable clues to physiological divergences. The succeeding chapters on the species problem and on mosquito classification and distribution are intended to summarize material bearing directly on the problems of evolution. Since I hope that the book will be useful for reference for people actively engaged in mosquito research, a chapter on techniques has been added."

This statement by the author summarizes in a few words and in a broad way the contents of the book. Throughout the work the author has drawn freely from his extensive experience with mosquitoes in the Mediterranean region and in Tropical America.

The work is divided into 20 chapters with an appendix consisting of a systematic list of mosquito species, referred to in the text with their general distribution, bibliography of 552 titles and a fairly satisfactory index. The five chapters following the introduction are devoted to the adult including habitats and biting, flight, sexual and oviposition habits. Chapter 7 deals with the egg in satisfactory style. Chapters 8 to 11, inclusive, consider the larvae including habits, physiology, development and enemies. In the discussion of enemies the author might well have included reference to the comprehensive bibliography of Gerberich on fish as mosquito predators (Amer. Midland Nat., July 1946). The pupa stage is briefly (7 pages) treated in chapter 12.

One should not expect to find in a generalized work of this kind a continuous story of any one species, but rather a composite story. The author has presented well chosen examples of the wide diversities in life cycles and habits to illustrate this composite story.

Chapters 13 to 15 are excellent summaries of the relation of mosquitoes to other organisms including their part in the transmission of diseases. The summary of mosquitoes as vectors of viruses will be found especially useful to medical men.

Some of the problems of the taxonomist are touched upon in Chapter 16 while in Chapter 17 the classification of mosquitoes is broadly discussed.

The classification of Edwards is followed including the use of the name *Culex fatigans* Wied. for the southern house mosquito which we in the U. S. call *Culex quinquefasciatus* Say. The distribution of mosquitoes by faunal regions is taken up in a general way in Chapter 18 with a good set of references to the literature. Some excellent suggestions on techniques of mosquito study are given in Chapter 19 but obviously the coverage of such a broad subject could not be considered in detail in a book of this type.

In the final chapter on the strategy of mosquito research the author again emphasizes his feeling that mosquitoes should have more attention from the biological viewpoint as is illustrated by his statement, "In the area of medical entomology, the development of new and fruitful conceptual schemes would seem to me to depend on a radical shift in point of view; a shift, in fact, from the strategy of medicine to the strategy of biology, since advances in the application of biology must

necessarily depend on advances in biological theory."

The difficulty of including references to all of the important contributions in a field so broad as that attempted by the author is obvious. But it would seem that some of the material rather remotely related to the special theme might have been reduced so that references could have been included to such pertinent articles as the summary of "Mosquito Culture Technique" by Helen Louise Trembley (Mosquito News, Dec. 1944), the paper "Biological Characteristics of Laboratory Reared *Aedes atropalpus*" by the same author (Jour. Econ. Ent., June 1945), the article by M. Greenwald *et al* on the large-scale rearing of *Anopheles quadrimaculatus* (Mosquito News, June 1948), the discovery by Rozeboom (Science, Aug. 1, 1941) of the interrelation between *Anopheles bellator,* bromeliads and malaria, Hearle's "Mosquitoes of the Lower Fraser Valley, British Columbia" (Rept. 17, [Canad.] Natl. Res. Council 1926), King and Rosario's "The breeding habits of *Anopheles litoralis* and *A. indefinitus* in salt-water ponds" (Philippine Jour. of Sci., July 1935), Bradley's ecological study of *Anopheles* in northeastern Louisiana (South. Med. Jour., May 1932), the experience of M. A. Barber in rearing anopheline larvae on pure cultures of food organisms (USPHS Rpts., June 3, 1927), Gjullin's studies on the effect of clothing color on the rate of mosquito attack (Jour. Econ. Ent., June 1947), and Clarke's report on flight range and longevity of mosquitoes (N. J. Mosquito Extermin. Assn., Proc. 30, 1943).

The vast amount of research on *Plasmodium gallinaceum* transmission is given little attention. For example, reference to the ease with which *Aedes atropalpus* is infected (Trembley, Jour. Parasit., Oct. 1946) is omitted.

The author states (p. 84) that no *Anopheles* has been reported to lay eggs without a previous blood meal yet Markovich observed this in *Anopheles claviger* (Med. Parasitol. 7(6), 1938). Although not mentioned, *Aedes atropalpus* has been reported by Trembley (Jour. Econ. Ent., April 1947) to have been carried through 26 generations without access to blood.

The author has tackled a big job and on the whole has done a creditable one, giving the entomologist, the sanitary engineer, the medical man and student of animal behavior a useful reference work.—F. C. Bishopp.

CONTROL OF RURAL MALARIA WITH D.D.T. INDOOR RESIDUAL SPRAYING IN KANARA AND DHARWAR DISTRICTS, BOMBAY PROVINCE: SECOND YEAR'S RESULTS, 1947–1948. By D. K. Viswanathan and T. Ramachandra Rao (Indian Jour. Malariol. 2(3):157–210, 1948. For centuries the Kanara and Dharwar Districts of Bombay have been malarious and have suffered from a gradually declining population. The vector in the Kanara District, *Anopheles fluviatilis,* usually rests outdoors, but when indoors, it prefers houses to cattle sheds. This species is highly anthropophilic. *A. culicifacies,* the carrier of malaria in the Dharwar District, prefers cattle sheds to houses as a resting place during the day.

In order to control malaria in these districts, DDT was applied at the rate of 56 mg. per sq. ft., as was done in the first year of the campaign. Spraying took place once in 2 months against *A. fluviatilis* in houses and once every 6 weeks against *A. culicifacies* both in houses and in cattle sheds. The DDT soap emulsion continued to be the main material used.

As a result of spraying operations during the second year, *A. fluviatilis* has been reduced 99% and *A. culicifacies* 90% as compared with 90% and 70–80% respectively for the first year. Spleen rates in the Dharwar District have been lowered from 19.6% to 10.6% and in the Kanara District from 14.4 to 11.6%. In addition, there were 300–400 less malaria deaths in each of the 2 years, 1946 and 1947. It is estimated that at least 300,000 cases of malaria have been prevented.

The second year's program, covering the largest rural malaria control project ever undertaken in India, has fully confirmed the earlier promising results. During the entire year only 3 specimens of *A. fluviatilis* were collected from sprayed houses in the Kanara District and 20 specimens were caught in unsprayed cattle sheds in the treated areas. In the untreated villages of Kanara, 350 specimens of *A. fluviatilis* or about 1.75 per 10 man hours of collecting were found, being far less than the assumed critical density. In the Dharwar District the density of *A. culicifacies* was a little over 5 per 10 man hours in the unsprayed villages.

During this whole spraying operation, there has not been a single instance of any bad effects due to DDT. Even the 150 members of the staff who handled DDT day in and day out suffered no ill effects during the 2 years' campaign. The success of this program is such that many other villages are clamoring for DDT spraying whether they have malaria or not, because of the control of other insect-borne diseases. The Government of Bombay has sanctioned the institution of a similar program for every village in the Thana District, an area which has a total population of 618,000.—Helen Sollers, Bur. Ent. and Plant Quar., U. S. Dept. Agr.

AIRCRAFT AND PUBLIC HEALTH SERVICE FOREIGN QUARANTINE ENTOMOLOGY. By J. H. Hughes. Supplement 210, Publ. Hlth. Repts., 37 pp. July 1949. Aircraft transactions totaling 215,992 were completed by the Foreign Quarantine Division of the Public Health Service at ports under United States control during the 18-year period 1930 to 1947, inclusive. Approximately 50 percent of this number of planes had entomological significance.

An aircraft disinsectization program, development of which was begun during the early 1930's, had been expanded to meet the foreign quarantine requirements of the Public Health Service. This program has been supplemented by the

entomological surveillance of airport areas and other areas of quarantine interest.

Requirements are given regarding an insecticidal aerosol and its use on aircraft, particularly in the control of mosquitoes and flies.

Findings based on an extensive entomological surveillance program conducted particularly in airport vicinities include one new species of mosquitoes, *Aedes keyensis,* and several records of mosquitoes reported for the first time in the United States. *Anopheles albimanus,* a malaria transmitter in the Caribbean region, was collected in a light trap as far north in Florida as the quarantine station at Fisher's Island, Miami Beach.

A summary is made for aircraft transactions for the period 1938–47, based on findings at Brownsville, Fort Worth, Honolulu, Miami, New Orleans, San Juan, and Terminal Island. During this 10-year period, 80,716 aircraft were inspected for entomological purposes. Of these aircraft, 28,752 (35.6 percent) harbored all entomological specimens found; 3,873 planes (4.8 percent) harbored the mosquitoes. The entomological findings on all planes inspected totaled 106,106 specimens of insects and other arthropods. During the entire period all arthropods found averaged 131.5 per 100 aircraft inspected. Mosquitoes numbered 12,825 for the entire period, with an average of 15.9 per 100 planes inspected.

Most of the insects found belong in the order Diptera (flies, mosquitoes, and others). During 1945, Diptera comprised 78.6 per cent of all entomological findings for the year; 57.8 percent of these Diptera were the housefly, *M. domestica.*

A list was prepared showing the mosquitoes found on aircraft during the 10-year period considered in this report. Ten genera and 73 species of mosquitoes are recorded. The genus *Culex* comprised 70.2 percent of the mosquito specimens. Two and four-tenths percent of all mosquitoes were anophelines.

Thirty-seven species of mosquitoes reported do not occur in all three of the general areas considered. A tabulation has been prepared showing these species, their general geographic distribution, and probable minimum distance transported from their place of origin to the port of interception. Twenty-five species of the mosquitoes found, including 11 species of anophelines, are not indigenous to the United States, Hawaii, or Puerto Rico.

Several species of mosquitoes found are known or suspected transmitters of the causative agents of malaria, dengue, filariasis, encephalitis, and probably other diseases.

Aircraft entomological transactions and findings for the 1945 fiscal year are presented in detailed tabular form. All but 68 of the specimens found during 1945 were insects. Twenty orders, 191 families, 680 genera, and 524 species of arthropods were identified. The total number of arthropod specimens found on 12,367 aircraft was 24,766. During 1945, *Anopheles pharoensis,* a malaria mosquito from Africa was intercepted at Miami; *Anopheles maculipennis aztecus* was first intercepted in this country on a plane which arrived at Brownsville from Mexico.

A tabular comparison of data by month for the 1946 entomological transactions is given.—Author's summary.

Da Aplicação Extradomiciliar de Hexaclorobenzeno Por Meio de Helicóptero no Combate aos Anofelinos do Sub-Gênero Kerteszia em Matas Primárias com Predominância de Bromélias Epífitas. By Ferreira, M. O., Rachou, R. G., and Bustamante, F. M. Revista Brasileira de Malariologia 1(2):24–34. April 1949. The companion paper compares the results with two different formulations of benzene hexachloride used under similar conditions. The dust formulation, containing 1.5 per cent of gamma isomer, caused a reduction of 99 per cent in adults two days after application, but had little or no effect on their larvae in bromeliads. The wettable powder, containing 6.5 per cent gamma isomer in 10 per cent aqueous suspension, gave a kill of adults up to 100 per cent between the third and 12th day after application, and a 90 per cent reduction in larvae 3 days after treatment. The cost of application favored the dust, as the helicopter applied it in less time than the aqueous suspension.—W. H. W. Komp, National Institutes of Health, Bethesda, Md.

Alameda County Mosquito Abatement District, 1949 Annual Report by Harold F. Gray. The most interesting event during the year was the discovery that the irrigated pasture mosquito *Aedes nigromaculis* found its way into a relatively isolated area of the district from the San Joaquin Valley where it is a severe pest. They hope to be able to keep it in this area, or if possible, extirpate it. The results of this effort will be of future interest. The author states: "Drain systems on the marshes within the district have been improved, extended and maintained. Considerable areas have been reclaimed by dikes and tide gates or by fills, much of it being performed by official agencies or private owners." This is of interest because it shows that the district's operations have continued to follow the tried and proven methods and that DDT has been used simply as a tool and not an exclusive method of control.

All phases of the district's activities are included, from the membership of the Board to the disbursement of the $96,601.40 spent in 1948. It also contains many interesting sections that cover a wide field of operations. The reports on virus studies pertaining to enchephalitis in which 2,227 specimens of species considered as vectors were submitted to the laboratory, all of which proved to be negative, is of interest.

During the year it was necessary to retreat only 35 underground utility vaults of the 2,747 vaults given a residual DDT spray of wettable powder in 1947.

The State Subvention program is mentioned in three or more places in the report. The dissatisfac-

tion or misunderstandings pertaining to this program are discussed.

The author also reports a small amount of residual fly control work, as well as giving assistance to a canning house having difficulty with fruit flies. This, considering the eminence of the author, should help to settle the much discussed point as to whether mosquito districts should undertake activities of this nature. — Fred H. Stutz, Dade Co. Anti-Mosquito District, Miami, Fla.

DA APLICAÇÃO EXTRADOMICILIAR DE DDT POR HELICÓPTERO NO COMBATE AOS ANOFELINOS DO SUB-GÊNERO KERTESZIA EM MATAS PRIMÁRIAS COM PREDOMINÂNCIA DE BROMÉLIAS EPÍFITAS. By F. M. Bustamante, M. O. Ferreira, and Rachou, R. G. Revista Brasilleira de Malariologia 1(2): 1–24. April 1949. Those of us who deal with Anopheles of normal habits may find the idea of a species whose larvae live at tree-top height somewhat fantastic. Nevertheless, in the State of Santa Catarina in southwestern Brazil, several species of the subgenus *Kerteszia* breed in large bromeliads (airplants) in the tops of tall forest trees. They are responsible for a serious malaria problem in the towns and villages situated in forested areas. Removal of the bromeliads by hand has proved costly and dangerous to the workmen. Cutting down the forest around inhabited areas has likewise proved costly. The application of a dust containing 10 per cent DDT by a Bell model 47 helicopter resulted in a reduction of 99.8 per cent in adults two days after treatment, and a continuing effect for as long as 25 days. Larval reduction of 77 per cent was obtained 24 to 48 hours after dusting. The helicopter is considered superior to a conventional airplane, as it needs no landing-strip and is more maneuverable.—W. H. W. Komp, National Institutes of Health, Bethesda, Md.

EXPERT COMMITTEE ON INSECTICIDES. REPORT ON ITS FIRST SESSION, CAGLIARI, 10–15 MAY 1949. World Health Organization, May 30, 1949. In English. This mimeographed report of 42 pages was sent to the Reviews Editor and may be borrowed by any AMCA members requesting it. Some of the subjects discussed in the sections are: specifications for DDT; disinsectization methods for quarantine purposes; measures to prevent introduction of anophelines into areas free or freed from them; role and limitations of insecticides in domestic fly control; interchange of information and literature; waiving of customs duties on material for insect control; harmlessness of DDT to man; and methods for the determination of the chemical composition and physical characteristics of technical DDT. Interesting report—recommended.—H. L. T.

FILARIASIS CONTROL BY DDT RESIDUAL HOUSE SPRAYING, SAINT CROIX, VIRGIN ISLANDS. I. OPERATIONAL ASPECTS. By Charles E. Kohler, Pub. Hlth. Repts. 64(27):857–862. 1949. The operational phases of an island-wide DDT spraying program to control filariasis transmission by destroying its mosquito vectors on St. Croix, Virgin Islands, are discussed. The medical and entomological phases of the program were carried out by the staff of the School of Public Health, Columbia University, and are reported in the article which follows. The residual spraying was under the direction of the Communicable Disease Center of the Public Health Service, San Juan, Puerto Rico. —Author's Summary.

Editor's note: The following is quoted from the article: "Based on experience in operating the program to date, the following recommendations for continued operations are indicated:

1. Use a spray crew consisting of one foreman and two sprayers.

2. Make two complete sprayings of the island each year.

3. Use new transportation; the time lost in maintaining old trucks is considerable. The remoteness of the island makes mechanical failures difficult to remedy.

4. Most of the houses on the island are poorly constructed and about 80 percent have absorbent interior surfaces. Therefore, 50 percent wettable DDT, since it is applied in particulate form, may be more suitable than solutions or emulsions, and its effectiveness should be determined. Modification of present equipment or the securing of new equipment which would be suitable for applying water suspensions would be necessary." (St. Croix is approximately 21 miles long with a maximum width of 6 miles, and a total area of 84 sq. miles.)

FILARIASIS CONTROL BY DDT RESIDUAL HOUSE SPRAYING, ST. CROIX, VIRGIN ISLANDS. II. RESULTS. By H. W. Brown, and R. W. Willliams. Pub. Hlth. Repts. 64(27):863–875. 1949. The control of *Wuchereria bancrofti* by a DDT spray program of human habitations over a 21-month period was carried out on the island of St. Croix, Virgin Islands, with the following results:

1. The population of *Culex quinquefasciatus,* the vector of filariasis, was reduced approximately 50 percent in the houses.

2. The number of houses in which *C. quinquefasciatus* could be found was reduced by 57 percent.

3. There was a 50 percent reduction of *C. quinquefasciatus* containing forms of *W. bancrofti* which had advanced in development beyond the exsheathing of the microfilariae.

4. Befeore the spray program, 0.40 percent of all *C. quinquefasciatus* examined harbored infective stages of *W. bancrofti.* After the spray program, not a single infective-stage larva was found in any mosquito.

5. *Aedes aegypti* was completely eliminated from the houses.

6. The *W. bancrofti* infection rate in school children dropped from 13.3 percent to 10.6 percent during the spray program, and the average microfilaria count fell from 74.1 per 0.04 ml. of

blood to 45.8. The differences are not quite statistically significant by conservative criteria.

7. Of 504 children examined in 1946 and again in 1948, a total of 454 were negative both times. Twenty individuals experienced increases in microfilaria counts, averaging 14 per 0.04 ml. of blood, while the counts of 30 individuals decreased an average of 46 per 0.04 ml. during the spray period. —Author's summary.

MOSQUITO CONTROL OF RICHLAND, WASHINGTON, IN VIEW OF OPERATIONS OF 1948. Released by the Mosquito Control Committee Representatives of the Atomic Energy Commission, Medical, Transportation, Labor and Community Management Divisions of the Hanford Workers.

A pictorial report with some dozen pages of pictures illustrating the mosquito problem encountered in this area with a short statement accompanying each picture relative to their control activity. This report is put together in ideal form for presentation to laymen and to residents of a mosquito district. ONE OF THE BEST THAT I HAVE SEEN TO ENCOURAGE RESIDENT PARTICIPATION IN A MOSQUITO CONTROL PROGRAM, this type of report could well be used as a pattern for conveying your local problems to the residents of your district.—C. T. Williamson, Suffolk County M.C.C., Yaphank, L. I., N. Y.

THE PLACE OF NEW AND OLD INSECTICIDES IN MOSQUITO CONTROL IN NEW JERSEY. By J. M. Ginsburg, D. M. Jobbins, and T. D. Mulhern. Proc. N. J. Mosquito Ext. Assoc. 36:136–143. 1949. The purpose of this paper is to prescribe as well as compare the various older insecticides, pyrethrum and oil, with those more recently developed, D.D.T. and D.D.D. The efficiency of control and its relation to safety as well as the economy of these toxicants are emphasized. In reading this paper, one is assured by the authors that the use of D.D.T. and D.D.D. have found a definite place in the field of mosquito control; however, they do not completely replace the permanent control. There has been and will continue to be research on the new toxicants because of the relative effect on plants and animals as well as humans. D.D.T. larvicides for the various types of control operations are discussed and suggested proportions are also given very completely, yet concisely. The reader can gain some suggestions from these formulas. Residual sprays, catch basin treatment, and pre-breeding treatment of D.D.T. as well as its use as an adulticide are given worthy note.

It is an admitted fact that D.D.T. can be injurious to various members of the animal kingdom when this compound is not properly applied or is used in places of possible injury to man or animals. However, to change the words of the authors of this paper, yet give the same meaning, we now have a rather cheap and efficient compound to aid in temporary mosquito control that we did not have knowledge of before the war. It is cheap as to cost and ease of application, efficient as oil or pyrethrum in its toxic effect on larvae and adults; however, not as toxic as oil for the pupae. Furthermore, D.D.T. has more types and forms of application than the older insecticides. To quote the authors, "Each one serves a useful purpose in mosquito control." Now, it behooves the various Mosquito Control Agencies to follow the suggestions and findings of the New Jersey Experimental Stations and aid them in their four points of further research as follows:

"1. To establish effective D.D.T. formulations for prebreeding treatments.
"2. To improve the penetrating properties of D.D.T. sprays on waters covered with dense vegetation.
"3. To increase the effectiveness of D.D.T. on pupae by the addition of either pyrethrins or synergic compounds.
"4. Improvements in the use of aircraft for effectively depositing required quantities of D.D.T. on large flooded areas, not accessible to ground applications."—P. Bruce Brockway, Jr., Toledo Area Sanitary District, Toledo 12, Ohio.

IMPLICATION OF THE MOSQUITO *Aedes (Stegomyia) africanus* THEOBALD IN THE FOREST CYCLE OF YELLOW FEVER IN UGANDA. By A. J. Haddow, K. C. Smithburn, G. W. A. Dick, S. F. Kitchen, and W. H. R. Lunsden. Ann. Trop. Med. and Parasitol. 42(2): 218–223. 1948. Since 1944 we have suspected that an arboreal mosquito, *Aëdes (Stegomyia) africanus* Theobald, is involved in the transmission of yellow fever among monkeys in Uganda. We have, therefore, made numerous mosquito catches in trees since that year, and we have established large numbers of sentinel rhesus monkeys on platforms in trees in our main study-areas, Bwamba county and the forests near Entebbe.

During September, 1947, a sentinel monkey, stationed in the forest-canopy near Entebbe, became immune to yellow fever. This indicated that the vector of the disease among monkeys in this region must be arboreal in its habits. In December of the same year, a rhesus monkey died 12 days after receiving a single inoculation of a suspension of *A. africanus,* taken in uninhabited forest in Bwamba. A routine test of blood taken before the inoculation had shown the monkey to be non-immune to yellow fever. Blood specimens taken shortly before and immediately after death, on the 12th day following inoculation with the mosquito suspension, contained neutralizing antibody against yellow fever virus. It is concluded that the *A. africanus* were infected with yellow fever virus, and that this species is involved in the forest cycle of yellow fever.—Author's summary.

CATCHES OF BITING DIPTERA IN UGANDA, WITH ANAESTHETIZED MONKEYS AS BAIT. By A. J. Haddow and G. W. A. Dick. Ann. Trop. Med. and Parasitol. 42(3/4):271–277. 1948. 1. Twenty-four-hour catches of biting Diptera, with anaesthetized monkeys as bait, were made in forest in Bwama county and in the Entebbe area, Uganda.

In two cases the catches were made in the forest-canopy only. In the first of these, redtail monkeys *(Cercopithecus nictitans mpangae* Matschie) were used, and in the second "grey" or "grivet" monkeys (*C. aethiops centralis* Neumann). The third catch was made simultaneously in the canopy, at understory level and at ground level, with rhesus monkeys (*Macaca mulatta* Zimmermann) used as bait.

2. In all three catches the most abundant mosquito biting the monkeys was *Aëdes (Stegomyia) africanus* Theo., a species which we know to be involved in the forest cycle of yellow fever in Uganda. Other prevalent species in the forest-canopy were *A. (S) apicoargenteus* Theo. and the tabanid *Chrysops centurionis* Aust., which we suspect to be a vector of filariasis among Uganda monkeys.

3. It is known that, with monkeys used as bait, *A. africanus* and, to a lesser extent, *A. apicoargenteus* form a much larger percentage of the catch than when African catchers, using themselves as bait, are employed. *Taeniorhynchus* spp. and *Anopheles (Myzomyia) gambiae* Giles appear, on the other hand, to attack man more readily than monkeys.

4. It is concluded that *A. africanus* and *A. apicoargenteus* probably feed mainly on monkeys in nature.

5. So far, we have recorded 15 species of mosquitoes and one tabanid *(C. centurionis)* biting monkeys in Uganda. Of the mosquitoes taken biting monkeys in trees an exceedingly high proportion (86 per cent) belong to species which normally breed in tree-holes.—Author's summary.

RECOVERY OF ANOPHELINE EGGS FROM NATURAL HABITATS, AN AID TO RAPID SURVEY WORK. By T. H. G. Aitken. Ann. Ent. Soc. America 41(3): 327–329. 1948. In this short article, the author points out the value of making anopheline egg collections under natural conditions. Immediate specific identifications can be obtained in the field, and a survey can be made of uninhabited regions where adult anophelines are difficult to find. Aitken writes from experience gained during a survey in May–August 1948 at Sardinia, an island lying west of the Italian peninsula, approximately 9,300 sq. miles in area, with most of it at altitudes of about 1,600 ft. or more. Over 9/10 of the population of 1,222,000 live in village centers. The author recommends that ordinary dipper samples be examined for mosquito eggs floating with the debris; these eggs can be readily removed by means of straws or the dried spiky leaves of wire grass *(Eleocharis)*. A tentative identification is made with a 20X hand lens, then the eggs are placed on strips of blotting paper soaked in 2% formalin and stored in small glass vials. In the survey reported, eggs recovered included those of *Anopheles labranchiae, A. melanoon, A. claviger,* and *A. algeriensis*. During the following season, the species incidence was confirmed by other types of collections. The author believes that consideration should be given this technique in other localities, such as in South America, where confirmation of *Nyssorhynchus* species frequently requires examination of the eggs, or in North America, where such studies of the *A. crucians* group might be advantageously undertaken. Because the collection of eggs from algal mats is very easy, the algal mat inhabiting *A. pseudopunctipennis* and its varieties should lend themselves to investigations involving eggs. (Ed. Note: The author may be addressed, Thomas H. G. Aitken, IHD, The Rockefeller Foundation, % ERLAAS, Piazza Garibaldi, Cagliari, Sardinia, Italy.)

—H.L.T.

A MALARIA RECONNAISSANCE OF THE STATE OF VERACRUZ, MEXICO. By José Bustos Castellanos, Lázaro Cerdán Murrieta, Guenther Lassman, and Carmen Ortiz. Am. Journ. Trop. Med. 29(1):23–35. 1949. A malaria reconnaissance of the State of Veracruz was conducted during 1944–46. Veracruz lies along the Gulf Coast of Mexico for about 960 kilometers (597 miles) with a width varying from 47 to 212 kilometers (29 to 131 miles). Most of the area is hilly or mountainous. The paper contains maps showing altitude, temperature, and rainfall zones. History, population, economy, and vital statistics are discussed briefly; and procedures of the malaria survey are given in detail. Although malaria is a serious problem, the State as a whole "can be considered as a zone of moderate malaria endemicity." There is less malaria at altitudes exceeding 1,000 meters (about 3,280 ft.). The incidence of *vivax* malaria increases with the altitude, while that of *falciparum* drops. A total of 45,949 Anophelines in 1,068 collections, was obtained. Species found were: *Anopheles albimanus, A. pseudopunctipennis, A. argyritarsis, A. punctimacula, A. apicimacula, A. neomaculipalpus, A. eiseni, A. vestitipennis, A. parapunctipennis, A. quadrimaculatus, A. strodei, A. crucians,* and *A. (Chagasia) bathanus. Albimanus* is probably the principal malaria vector, with *pseudopunctipennis* and *quadrimaculatus* also of importance.—H.L.T.

THE DEVELOPMENT AND PRACTICES OF THE ANTI-MALARIA CAMPAIGN IN ARGENTINA. Silvetti, Luis A., Inter-American Association of Sanitary Engineering, Vol. 2, No. 1, July, 1948. Three malarious areas exist in Argentina, two of which (northeast and west-central zones) are endemic, the other (Littoral Zone) being epidemic. *Anopheles pseudopunctipennis* is the sole vector in the endemic area and it exists as the only anopheline in arid Argentina. The vector/s has not yet been determined in the Littoral Zone, although *A. albitarsi* and *A. darlingi* are suspected.

The nature of anopheline control performed is dependent upon the human population density. Cities and the more important towns are protected principally by larval control. DDT house spraying for adult mosquito control is carried on in suburban and rural areas (and also in some cities of 5,000 to 15,000 population).

The anti-larval program utilizes knowledge of *A. pseudopunctipennis* ecology and its objective is to eliminate mosquito breeding areas where possible. A balanced combination of mechanical, chemical and biological measures is characteristic.

Adult control lends itself because of the domestic and anthrophilic habits of *A. pseudopunctipennis*. This is accomplished by DDT residual spraying of houses. Spraying is confined to living rooms and sleeping rooms. Retreatment is practiced at three-month intervals during the mosquito season.

Although it is not yet possible to fully evaluate the results of the program, house collection records show that adult anophelines have decreased markedly. The blood parasite index for *Plasmodium falciparum* has shown drastic reduction and dispensary cases have dropped appreciably.

The overall impression of the program received by the reviewer is that a maximum of resourcefulness is being applied to the problem with the resources available. It is hard to appreciate why crude oil should be used for weekly larval treatments when aqueous (emulsible) DDT could be substituted. It is also wondered why aqueous (emulsible) DDT is not substituted for much of the use of DDT in kerosene for residual adult control. No mention of the use of space sprays (fogs, aerosols, etc.) is made nor is the use of the airplane in applying aerosols indicated. Perhaps these approaches could supplement the program in places. A last wonder is whether entomological services in evaluating the program are being utilized to maximum advantage.—Richard F. Peters, Bureau of Vector Control, State Dept. of Health, Berkeley, California.


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